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LESSONS LEARNED FROM EXPERIMENTS CONDUCTED ON RADAR DATA MANAGEMENT SYSTEMS

BY

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The thesis provides lessons learned from experiments conducted by the 11th Air Force to verify the capabilities of two vendor-produced Radar Data Management Systems (RDMS). The first part of the thesis provides background information explaining the impetus for such experiments and why a lessons learned approach was taken. The experimental plan and the final report from the PACAF experiments are analyzed using evaluation tools taught in the C3 curriculum at the Naval Postgraduate School. The lessons learned from the mistakes made during these experiments are applied to produce a revised Experimental Plan. A lessons learned section follows the analysis. This section discusses specific lessons learned from the 11th Air Force experiments as well as more general lessons learned by the author. The thesis concludes with two chapters that provide overall conclusions and a summary, and recommendations for future work that can be accomplished in the area of radar data management.

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Lessons Learned From Experiments Conducted on Radar Data Management Systems

by

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Submitted in partial fulfillment of the requirements
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ABSTRACT

The thesis provides lessons learned from experiments conducted by the 11th Air Force to verify the capabilities of two vendor-produced Radar Data Management Systems (RDMS). The first part of the thesis provides background information explaining the impetus for such experiments and why a lessons learned approach was taken. The experimental plan and the final report from the PACAF experiments are analyzed using evaluation tools taught in the C3 curriculum at the Naval Postgraduate School. The lessons learned from the mistakes made during these experiments are applied to produce a revised Experimental Plan. A lessons learned section follows the analysis. This section discusses specific lessons learned from the 11th Air Force experiments as well as more general lessons learned by the author. The thesis concludes with two chapters that provide overall conclusions and a summary, and recommendations for future work that can be accomplished in the area of radar data management.

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I. INTRODUCTION

Pacific Air Forces (PACAF) is presently acquiring a radar data management system (RDMS). This system is intended to both reduce the amount of radar clutter presented to the operator and reestablish radar sensitivity which was deliberately reduced for reasons to be given below. The underlying problems that would be solved by acquiring a RDMS were due to the fact that radar technology was upgraded faster than the technology of the computers that process the radar data in the air defense command and control (C2) architecture. In 1983, a new generation of radar became operational. The gap between radar and computer technologies immediately created a problem; the collective input of radar data overwhelmed the central computer. To relieve this burden, engineering change proposals (ECPs) were implemented to reduce radar sensitivity and, thus, the amount of data forwarded to the central computer.

The ECPs were intended as a temporary solution, but they are still being used. The ECPs arbitrarily filter radar data and, as a result, actual targets may be filtered out, and air defense operations may be compromised. A more permanent solution is needed.

In 1990-1991, two defense contractors claimed to have developed radar data management devices that exploited new computer technology to reduced the volume of data in a more selective way. By using these devices, the radar could be restored to full operational capability, and the volume of data could still be kept small enough for the existing C2 computers to process. The possibility of overloading the computer would be small.

PACAF is anxious to exploit this technological improvement. It would allow them to better fulfill their mission requirements and still delay procurement of a

new generation of air defense computers. Before committing to this course of action, PACAF wanted to assess the validity of the two manufacture's claims, and identify the best system.

An experiment was conducted by the 11th Air Control Wing (ACW) at Elmendorf AFB, Alaska. The data collection had to be done in a manner that would not interfere with the performance of the Region Operations Control Center (ROCC) operational mission, but actual field trials were preferred to laboratory tests. As a result, the data collection operation was "piggybacked" onto normal operations.

When the 11th ACW attempted to analyze this data to see whether the manufacture's claims were true and to determine which manufacture's equipment performed better, they could not. They found that the massive volume of data collected did not include the information necessary to fully answer the questions: "Will the manufacture's equipment eliminate data on tracks necessary for the conduct of air operations? " The 11th ACW needed to be able to identify the tracks, but that information was not available.

The purpose of this thesis is to critically examine this case and document what went wrong. General questions such as:

> can experiments be successfully conducted within the operational environment?

will be addressed, but the primary emphasis will be on the PACAF experiment.

II. BACKGROUND

This chapter provides background information that is necessary to understand the following analysis of the PACAF experiment. The Impetus For Change Section explains the radar data management problems and why a solution is needed. The System Description Section describes the components directly involved with radar data management. A description of the RDMS as a potential solution along with the anticipated benefits to the command and control system are addressed in the Radar Data Management Equipment Description Section. Finally, the Special Considerations Section illustrates the challenges of conducting an experiment in an operational environment.

A. IMPETUS FOR CHANGE

The Alaska NORAD Region (ANR) was driven by several factors to change the way radar data was managed. The decline of the Soviet threat and resulting draw down of the American military machine was a principal factor. In 1990, the U.S. Air Force began a slow process of reorganization, within which the Alaskan Air Command (AAC) ceased to be a major command. It became the 11th Air Force, under the organizational command of Pacific Air Forces (PACAF). The reorganization meant that the 11th AF now had to go through PACAF for all of its funding, including justification of the funding for existing programs.

The eruption of Mount Pinatubo in Philippines and resulting loss of Clark Air Base was another factor. Clark Air Base was the location of an air training exercise called Cope Thunder, a major exercise PACAF used to train its forces in Asia. PACAF needed to fill the void left by the loss of Clark AB and thus Cope Thunder, and Alaska was seen as the best replacement. The Alaskan theater provided many opportunities: large training areas over sparsely populated areas;

the capability to add more training areas; in-theater tanker support; two large bases capable of handling an expanding number of fighter squadrons as well as accommodating visiting squadrons; a well established command and control network (ANR ROCC and AWACS (Airborne Warning and Control System)); and new developments for integrating theater wide command and control facilities that were already in progress (i.e., Commander's Theater Information System (CTIS) and Aircraft Combat Maneuvering Instrumentation (ACMI)).

PACAF decided to move Cope Thunder to Alaska, and plans were put together to expand the training ranges. But, radar coverage within the proposed training areas was not adequate to provide safe operations. Additional radars were needed, and an initial increment of two was requested to increase low level coverage. To be effective, the additional radars had to be integrated into the ROCC, but the central computer is a weak link because of its limited processing capability. Therefore, adding more radars, especially radars concerned with low level coverage, which produce more clutter than radars concerned with high level coverage, meant a much greater chance of overloading the ROCC central computer.

Radar data management became a key issue. Given the factors of limited time (PACAF was proceeding rapidly with the range improvement project), limited funding (most of the funding was going for range improvements), limited computer processing power of the ROCC computer, and limited sensitivity of existing radars caused by the ECPs; the 11th ACW staff knew one possible answer. They had been working on the issue of radar data management for over a year and knew of commercial-off-the shelf equipment that would be low cost, quickly installed, reliable, maintainable, and interoperable with the existing and

new radars and with the ROCC. This new equipment was available from two defense contractors.

The 11^{th} ACW was tasked with investigating both potential solutions and making recommendations about which, if any, system to use, and how to use it. The first major task was to confirm the claims made by the defense contractors. Experimental plans were drawn and experiments were run to test the systems. Would the RDMSs allow the ECPs to be removed from the radars to restore their sensitivity, and at the same time reduce the amount of clutter being sent to the central computer without eliminating valid air tracks?

The 11^{th} ACW staff was in charge of planning and executing the experiment, analyzing the data, and making recommendations about the radar data management systems. Shortly after the experiments concluded, the author, who was in charge of the experiment, was accepted to the Naval Postgraduate School (NPS). The data had not been closely analyzed, and with the training received at NPS, a thorough analysis finally could be done. Looking back, many mistakes had been made with the experiment, so many that a comprehensive analysis could not be done. Therefore, this thesis will examine what went wrong, propose a new plan, and provide lessons learned.

B. SYSTEM DESCRIPTION

The RDMS is aimed at solving the radar data management problem of the ANR, specifically the ROCC. The ROCC is the center for command and control in Alaska. This command and control architecture is described in the following paragraphs. First, roles and missions are examined, then the system components and their roles in radar data management are addressed.

1. Roles and Missions

Command and control is unique in Alaska, literally serving two masters. Operationally, the ANR reports directly to NORAD Headquarters. The mission is to provide "...warning of a surprise attack against North America, and surveillance, control, and defense of our sovereign airspace [Ref. 1]." Administratively, the 11th Air Force reports directly to PACAF for everything it needs to carry out its assigned mission.

2. System Components

Two components of the ROCC are directly involved with the radar data management problems, the long range radars, better known as Minimally Attended Radars (MAR) and the ROCC central computer located at the ROCC. They are described below. The radar data flows from the MAR to the ROCC central computer via a commercially leased satellite. The flow of data is depicted in Figure 1 [Ref. 2].

a. Long Range Radars

Long range radars are the heart of the Alaskan air defense network. Figure 2 depicts the approximate radar locations in Alaska. In 1983, a new type of radar became operational. "The AN/FPS-117 Minimally Attended Radar (MAR) is designed to provide long-range accurate aircraft identification and position data..." The MAR provides "...digital output messages containing range, azimuth, and height information for radar and beacon targets." [Ref. 3].

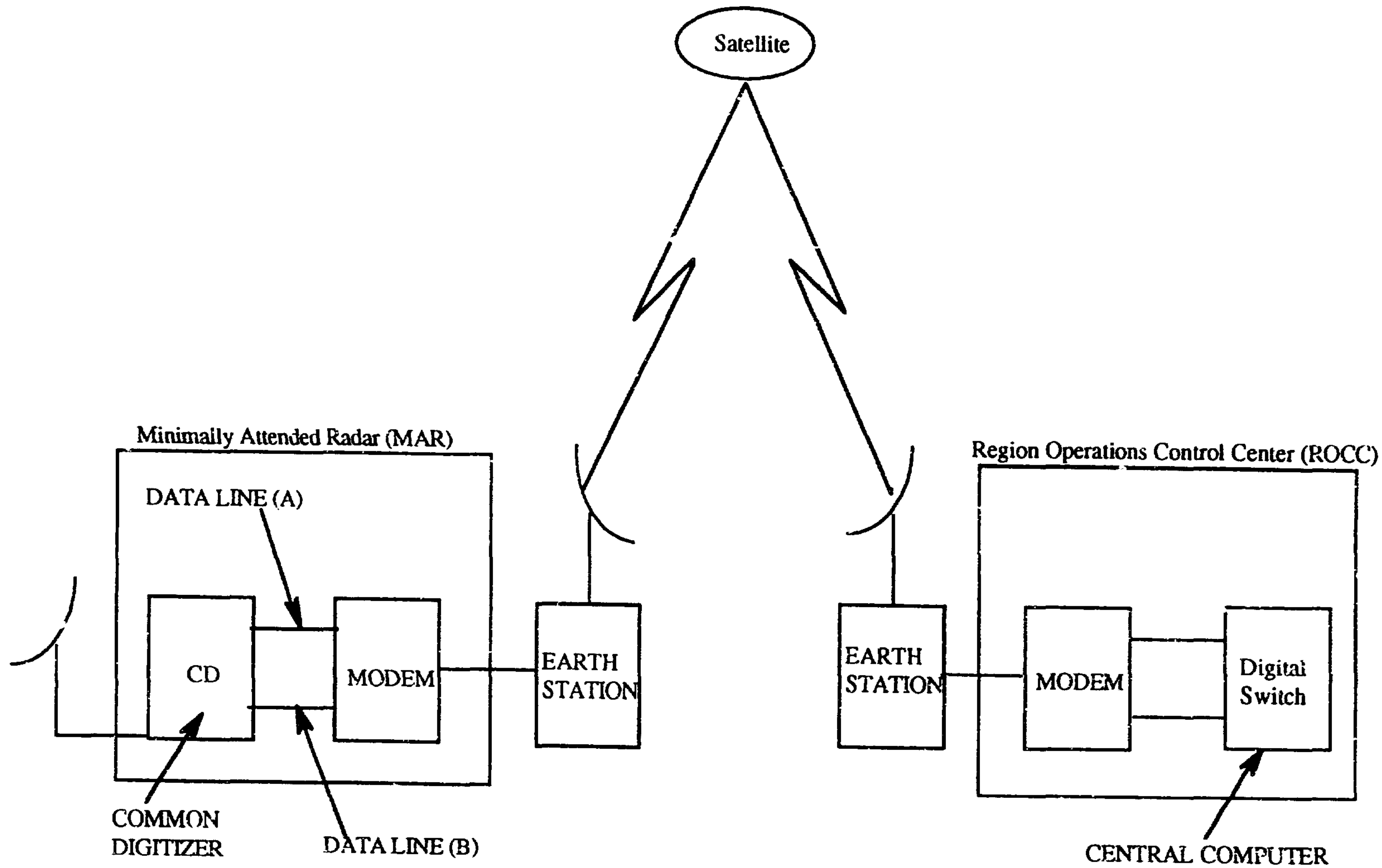
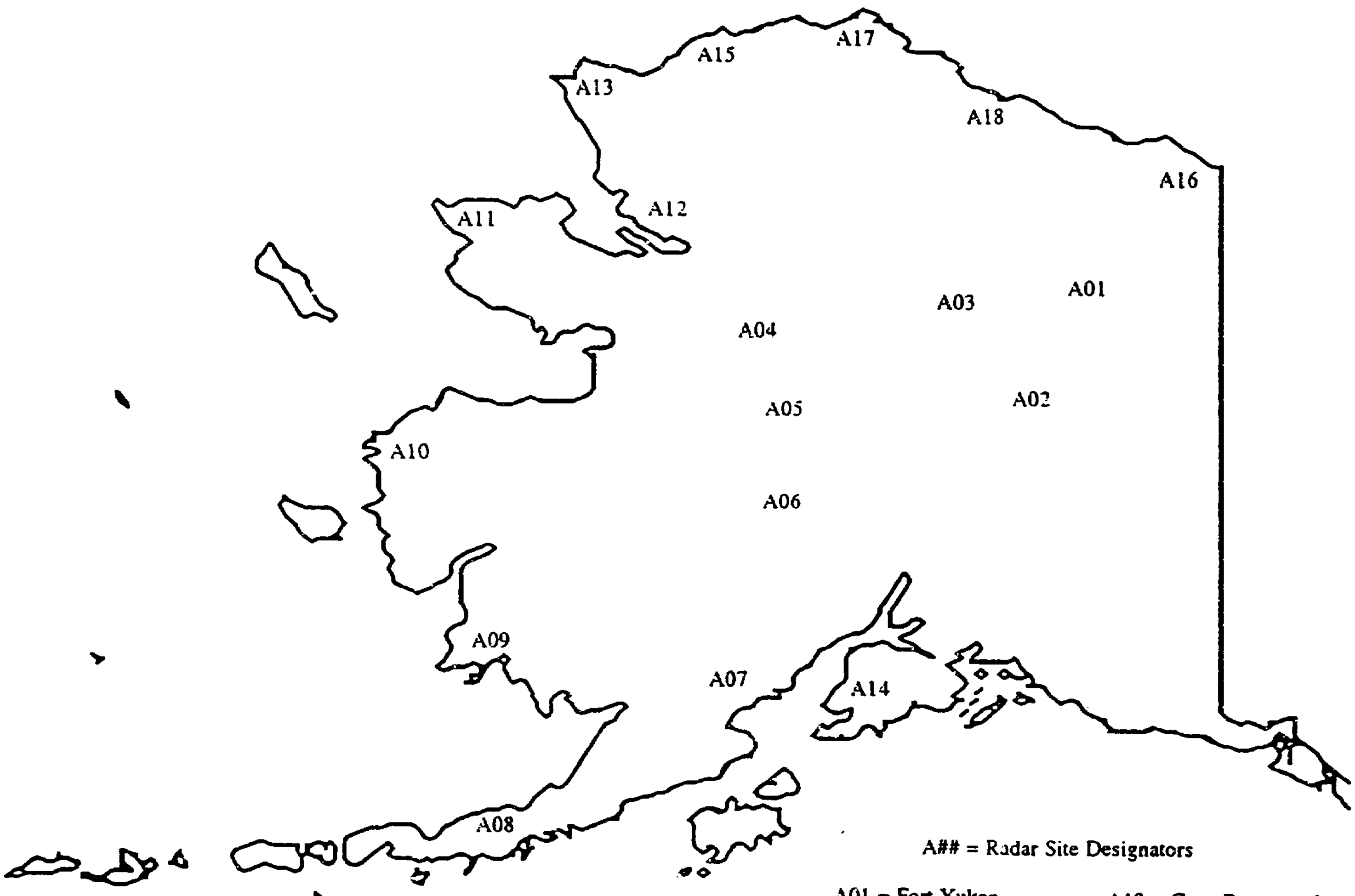


Figure 1 Radar Data Flow From MAR (Radar) Site to ROCC



A01 = Fort Yukon
A02 = Murphy Dome
A03 = Indian Mountain
A04 = Galena
A05 = Tatilina
A06 = Sparrevohn
A07 = King Salmon
A08 = Cold Bay
A09 = Cape Newenham
A10 = Cape Romanzof
A11 = Tin City
A12 = Kotzebue
A13 = Cape Lisburne
A14 = Kenai
A15 = Point Lay
A16 = Shingel Point
A17 = Point Barrow
A18 = Oliktok

Figure 2 MAR (Radar) Site Locations

Two radar-related factors contribute to the radar data management problems. The first factor is the extreme sensitivity of the radar. The unclassified operational characteristics of the radar provide an insight. Rotating 360 degrees every 12 seconds, the radar search volume is from 5 to 200NM, +6 to +20 degrees elevation, a 100,000 feet altitude limit, range resolution of .5NM, and a range accuracy of .25NM [Ref. 3].

The second contributing factor is the adverse clutter environment found in Alaska. "The clutter environment in Alaska is difficult for radar operation because of unique terrain, a wide range of temperatures, extreme weather, and a large migratory bird population [Ref. 3].

b. ROCC Central Computer

The ROCC Central Computer is the central point for processing the data received from all of the radar sites. This fully redundant computer is the Achilles heel of the entire data management process. (Figure 3 provides a block diagram of the fully redundant ROCC Central Computer [Ref. 4].) The main problem lies in the centralized role the computer plays. In every 12 second sweep, each radar forwards all of the data detected within its search volume. The data remains unprocessed until it reaches the computer at the ROCC. With 18 MARs located in Alaska, a vast amount of data must be processed by the computer. The computer processing time is synchronized with the radar sweep time of 12 seconds. If the computer is overloaded by too much data, then it arbitrarily "dumps" data in order to meet the 12 second processing time. Avoiding overloading the computer was the driving force for the clutter-reducing ECPs originally installed at the radars.

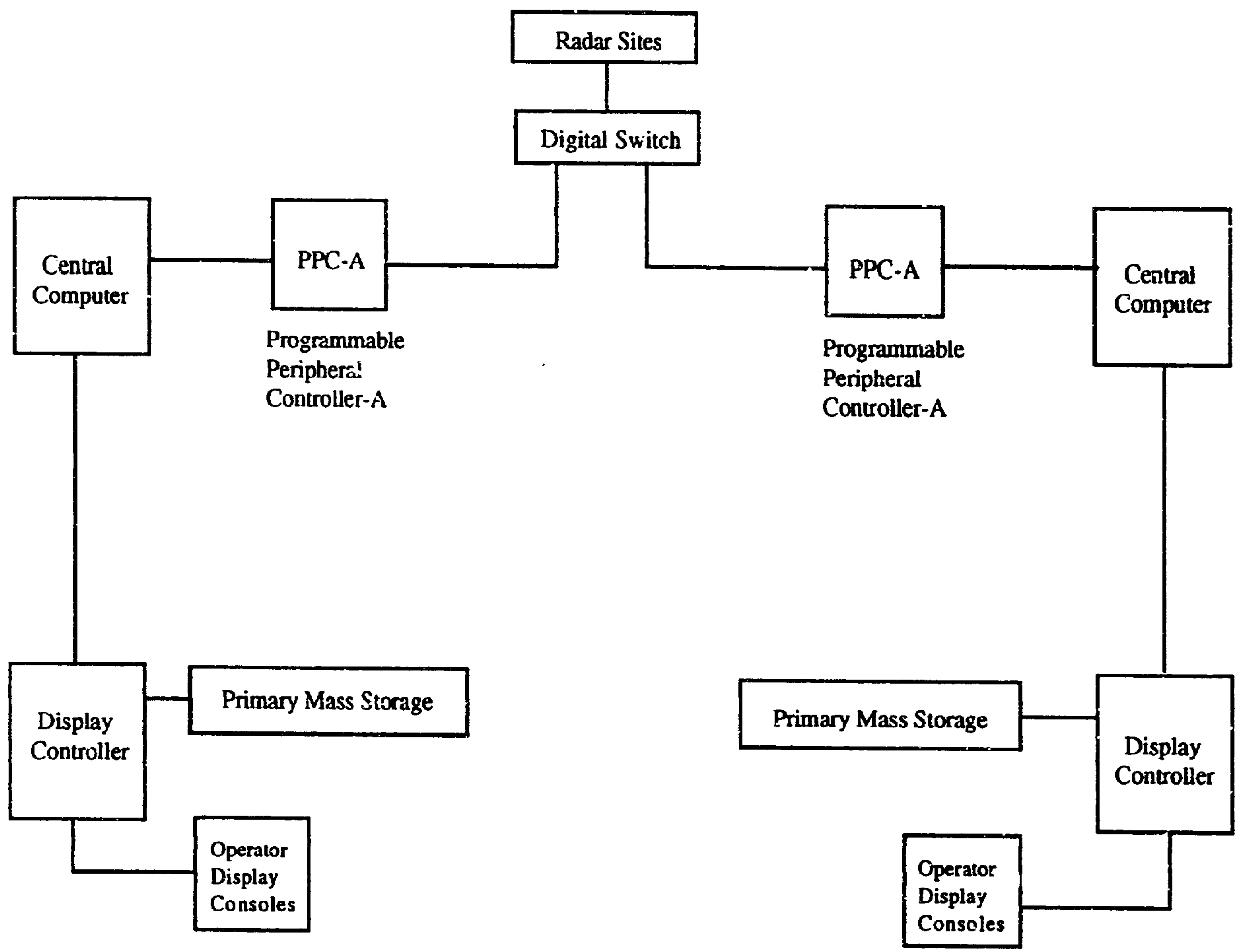


Figure 3 Block Diagram of a Fully Redundant ROCC Central Computer

A conflicting sequence of events has occurred: the new radars produce too much data because of their sensitivity and the location of each within a high clutter environment; the data from all 18 radars must be processed by older, slower computers; and the clutter reducing ECPs that were enacted to avoid computer overload sacrifice the sensitivity that the new radars provide.

C. RADAR DATA MANAGEMENT EQUIPMENT DESCRIPTION

Two vendors presented potential solutions to Alaska's radar data management problems. Litton Data Systems Advanced Tracking System (ATS) and Sensis Corporations Multi-Scan Correlator Model 2000 (MSC-2000). Both of these devices work on similar principles, based upon software algorithms designed to discriminate tracks from clutter.

1. General Description

Each radar data management device is a computer, with the hardware and software necessary to reduce the amount of clutter caused by environmental factors, while at same time maintaining a high level of radar detection. The heart of each device is the tracking algorithm. The specifics of these algorithms are considered proprietary to each vendor, and will not be addressed here. Generally speaking, however, the tracking function is performed by an adaptive algorithm. The algorithm is designed to detect and establish a track within a certain number of radar scans under varying amounts of search volume, store the track information in a file, and compare new track information to the existing file. The track information is kept in the file for a certain number of radar misses before the track is dropped. In order for the tracking algorithm to be effective, the radar's search volume is divided into thousands of azimuth and range cells. The tracking algorithm uses these cells to establish the validity of a track. Once a track is

established the RDMS sends only the track data back to the ROCC Central Computer [Ref. 5 and 6].

2. Benefits

One approach to solving the underlying problem in Alaska's radar data management is decentralized processing of the radar data. The Litton Data Systems and Sensis Corporation devices focus on this approach, decentralizing the task of radar data processing. If all 18 radars could preprocess their own raw data, forwarding only processed track data, it would significantly lessen the processing burden on the central computer, thus lessening the chances of overload. Several benefits can be immediately realized:

a. Restoring sensitivity to the radars without fear of overloading the computer will provide a higher level of operational capability. In the past, low level radar coverage was limited because it was the source of most clutter. The ECPs primarily focused on reducing the low level radar beam coverage. But, low level coverage would not be a problem using the vendor's devices because tracks could be discriminated from the clutter, and only track data would be passed on to the command and control computer. Lowering the radar beams would benefit both missions of the ANR: air defense, including detection of air-to-surface missiles; and training, which requires maintaining separation of aircraft for the safe conduct of operations within the training range.

b. The procurement of the next generation ROCC computer could be delayed. The limitations of the computer processing would be overcome not by developing a new ROCC computer, but by taking advantage of current computer technology to provide decentralized processing. A new ROCC computer would take many years to develop and cost more money than anyone would want to spend for an air defense command and control system. Research and

development for the vendor's RDMS is already accomplished--the systems already exist. The only task would be to ascertain the validity of the claims being made about these systems and determine which system best solves the radar data management problems.

c. Integration and interpretability are additional benefits. By reducing the workload of the central computer, additional radars could be easily integrated into the existing air defense network. This is especially important because the range improvement plans call for adding two additional radars. The radars under consideration are Westinghouse radars developed for the Marines and used to provide short range, low level radar coverage. Both vendor's RDMS are interoperable with a wide range of radars. This will provide flexibility when acquiring additional radars for future expansion of radar coverage. Deployed radars equipped with an RDMS device would also be able to provide track data to the ROCC computer for display.

D. SPECIAL CONSIDERATIONS

Operational mission constraints and legal ramifications are necessary background. Special considerations, driven by the operational mission, had to be accounted for in the planning and execution of the experiment. Whether or not these factors had a direct effect on the outcome of the experiment is hard to say. However these factors are worthy of mention. They illustrate the challenges of conducting experiments in the operational environment. Legal ramifications were always a topic of utmost importance. The commander emphasized that he did not want to give the perception that the 11th AF was in the business of conducting its own test and evaluation. Additionally, he did not want to give the impression that he was bypassing the acquisition process. Therefore, he informed all

involved with this project to make it clear: 11th AF had not gone into business for itself.

1. Operational mission constraints

The experiments would have to be conducted on a non-interference basis. The operational missions could not be sacrificed at the expense of the experiments. This criterion was the ultimate requirement and provided the boundaries for the experiment. A direct cause and effect relationship can be seen between the operational mission constraints and variable selection in the experiment. Furthermore, controlling factors in an operational environment is much more difficult than in a laboratory.

The 11th ACW staff wanted to vary certain factors, but was constrained by operational requirements. The factors that were affected were site selection, time, and type of radar. Only three sites were allowed as part of the experiment. Even these sites were subject to being removed if they were needed to fulfill an operational mission. The effect this had on the experiment was that it was now limited to the terrain, air traffic volume, and clutter unique to the three areas selected. This lead to several questions: Is this sample representative of the Alaskan environment as a whole? Could valid conclusions be drawn for the entire area of responsibility or just those sections? What about the areas where the new radars would be used? Since none of the radars selected is located in the proposed range improvement area, would the conclusions drawn from where the experiments were conducted be valid there?

Time was also affected by operational constraints. The time of year was limited to the early winter season. Would this be a representative sample for the type of traffic volume and clutter seen throughout the entire year? Additionally, the time of day was limited. The experiment could only be conducted before or

after the daily training sorties were flown. This meant either early morning or late afternoon/early evening. Again, would this represent an environment similar to one normally seen?

The radars used were a factor that should have been varied but could not be. Ideally, two different radars should have been examined: the MAR radar and the Marine short range radar. However, since the Marine radar had not been procured, only the MAR radar could be examined.

Weather, traffic volume, terrain, and clutter environment are all factors that the experimenter would like to either control or vary but were literally at the mercy of the operational constraints. These factors are all functions of the site selection and time. Therefore, holding them constant or allowing them to vary was impossible and reflected the difficulty of conducting controlled experiments in an operational environment.

2. Legal Ramifications

The term "demonstration plan" was used to emphasize the point that operational units were not in the business of test and evaluation. The 11th AF was conducting a demonstration of the equipment, at no cost or legal obligation to the government. Furthermore, the staff was going to examine the data the vendors collected to verify the claims of the vendors. The 11th AF did not want to give the perception that this unit was bypassing, or undermining, established acquisition procedures. In fact, the unit did not actively pursue vendors. The vendors made their own solicitation and offers of demonstration, at no cost to the government, and these offers were made prior to the range improvement project.

Up until this point, Litton Data Systems was the only vendor known to have a radar data management device. Not until after completion of the Litton Demonstration was it learned that there was another vendor that had a similar

device and wanted the opportunity to demonstrate it in Alaska. This created a potential legal problem. If, Sensis Corporation, the other vendor, wanted to demonstrate their equipment and were turned down, then the government could face a lawsuit. In order to afford Sensis the same opportunity as Litton, it was decide that Sensis could demonstrate their equipment. Because of the short notice of the Sensis demonstration, another Demonstration Plan was not produced. Instead, the ATS Plan was followed and the results of both demonstrations were published in the Long Range Radar (LRR) Enhancements Staff Study.

E. CONCLUSIONS

This chapter provided background information and serves as a prelude to the analysis of the experimental plan and report. The Impetus for Change Section illustrated why the 11th AF felt management of the radar data was important. The System Description Section detailed the components involved with radar data management. The shortcomings as well as the potential benefits of installing an RDMS were elaborated in the Radar Data Management Equipment Section. Finally, the chapter ended with a discussion of the special considerations and their affect on the experiment. With the background firmly established, an analysis of the experiment can be conducted. The experimental plan and report will be analyzed in Chapter III.

III. ANALYSIS

This chapter presents an analysis of the Advanced Tracking System (ATS) Demonstration Plan and the LRR Enhancements Staff Study [Ref. 7 and 8]. From this point on, the ATS Demonstration Plan will be referred to as the Plan and the LRR Enhancements Staff Study will be referred to as the Report. The reader is encouraged to read both the Plan and the Report which can be found in Appendices B and C. This will aid in understanding the analysis.

The Plan and Report analyses follow a simple format--mistakes are pointed out followed by potential solutions. An Experiment Plan and Reports Format and an Evaluation of Studies Paradigm that were presented in the C3 curriculum at the Naval Postgraduate School were used to analyze both the Plan and the Report [Ref. 9]. These tools are used to identify mistakes and to provide guidance for the solutions. The Experiment Plan and Reports Format and the Evaluation of Studies Paradigm are included as Appendices D and E. At the conclusion of the analysis, a newly revised Plan is presented that integrates all of the lessons learned in the Plan analysis (Appendix F). However, there is no newly revised Report. The main reason is that the data necessary to provide a thorough analysis is not available; therefore, major sections of the report would be missing.

The Experiment Plan and Reports Format serves as a model of how a plan and report could be organized and what elements should be contained in the structures of plans and reports. From this point on, the Experiment Plan and Reports Format will be known as the model (Appendix D).

The Evaluation of Studies Paradigm (Paradigm) is an essential ingredient in the analysis because it defines the elements of the model (Appendix E). Together

the model and the paradigm provide the framework needed to analyze the Plan and Report.

A. PLAN ANALYSIS

The ATS Demonstration Plan lacks a clear statement of the purpose of the experiment. Neither the real world problems that the ATS is intended to solve, nor how the results of the demonstration will be used to show that it can, are clearly stated. As a result, the following sections lack foundation. They should give details about the conduct of the experiment and the analysis of the results, and show how everything is specifically organized to answer the questions at hand. Without clear articulation of the problem, this is not possible. Detailed analysis of each section, as defined in the model, followed by a sample introductory revision is given below.

1. Mistakes (Introduction)

An experimental plan should be a cohesive document that lays the foundation for the entire experiment, up to and including the analysis. It should provide introductory material saying who is performing the experiment, why the experiment is being performed (purpose), and defining the experimental scope. This material should clearly identify the real world problem that the experiment will help solve and the specific questions the experiment seeks to answer.

The major problem with the Plan is its lack of a unified introduction section containing clearly defined objectives of what the experiment is supposed to do. The introductory elements that the Plan does contain are scattered throughout the plan as opposed to being incorporated into a unified introduction section. For example: the team is introduced in section 2-1; the purpose statement is found in section 1-1; and the objectives are found in section 4-1. This creates a lack of focus for the entire experiment.

The purpose is not fully addressed. There is a purpose statement, but it is rather weak. The Plan states the"...demonstration is to determine whether or not the ATS can be used in the Alaskan Theater to improve radar performance and make recommendations concerning the desirability of [incorporating] the ATS in the Alaskan Surveillance and Command and Control System." The purpose also mentions that the primary objective is to "...collect sufficient data to determine the ATS's capability for substantially improving the probability of detecting targets (at lower altitudes and clutter environment)." But, the real world problem is neither poor radar performance nor low probability of detection. The actual real world problem is radar data overloading the central computer. This is not mentioned. Furthermore, there are no specific questions that the experiment seeks to answer. So naturally, the approach the experiment will use to answer the research questions is not addressed and neither are the anticipated results. The scope of the experiment is also not addressed. This section should explain why this experiment is important to the success of the mission, what constraints are imposed on the experiment, and what the impact of the experiment will be.

The stated objectives are not appropriate because they are benefits rather than objectives, and they do not map back to the primary objective listed in the purpose statement: to provide evidence as to whether or not the ATS is capable of improving the probability of detecting low level targets in a high clutter environment.

Objective one states:

> Reduce demands on the FYQ-93 ROCC central computer; processing time and memory space. At present, central computer processing time and memory storage space is nearly saturated; while memory storage in the processor controller is overloaded to the point it "dumps" data.

Objective three states:

> Increase probability of detection by reducing human variability in the detection/tracking process. The ATS serving as a front end processor at the radar will automatically detect, establish, and pass target data to the Region Operations Control Center (ROCC). The presentation of only true targets in the ROCC will eliminate operator decisions concerning the validity of targets. This will increase the probability of establishing air tracks. Also because only true targets are presented, maintaining track continuity will improve for both computer tracking algorithms and when operators override computer tracking.

Neither one of these are valid objectives. Both of them are benefits that would result if the ATS works. However, determining the truth of this assumption is the primary objective of the experiment.

Objective two states:

> Radar Enhancement: Regain loss of probability of detection, sacrificed at the expense of clutter reduction solutions to the radar. With the ATS's ability to extract true targets from clutter, the radar beam could be lowered thus increasing the probability of detection of low level targets.

This objective is not appropriate because it is the approach that the experimenters are taking to test the ATS's capabilities. In order to validate the manufacture's claims about the ATS, the radar must be allowed to operate in its fully operational state uninhibited by any ECPs. The purpose is determine the amount of data being processed by the radar with and without the ATS, and to determine whether or not the ATS is eliminating valid target data.

Objective four states:

> Role of the ATS in Alaska: By analyzing the data collected during the demonstration, we will draw inferences concerning the utility of the ATS in Alaskan Theater. Areas of interest: advantages of incorporating the ATS at each AN/FPS-117 in Alaska from a sensor interoperability standpoint; added measure of safety in large scale exercises.

This objective is neither a benefit nor an approach. Instead objective four is a conclusion that can only be made after the data is collected and the results analyzed.

2. Solutions (Introduction)

The major problem with the Plan is its lack of a unified introduction section containing clearly defined objectives of what the Plan is supposed to do. The solution is to create an introduction section that corrects the mistakes. An example of what the introduction section should look like follows:

I. REVISED INTRODUCTION

A. Project Management

The 11 ACW is going to conduct an experiment to assess the capabilities of the Litton Data Systems Advanced Tracking System (ATS).

1. In order to manage the demonstration, an Advanced Tracking System Project Management Team was established. The demonstration team leader is 11^{th} ACW/DOX; other team members are listed in paragraph three.

2. The following agencies are participating or providing support for the ATS demonstration:

a. 11 ACW/DOXXQ -- Capt Pierce

b. 11 ACW/DOP -- SSgt Myher

c. 11 ACW/LGOR -- MSgt DeLuca

d. 11 ACW/LGKC -- MSgt Shuler

e. 11 ACW/LGKM -- TSgt Cushman

f. 744 ADS/DOO -- Lt McNeil

g. 21^{st} TFW/DOW -- Capt Hill

B. Purpose

The purpose of this experiment will be to determine whether or not Litton Data Systems Advanced Tracking System (ATS) is capable of more efficiently managing the flow of radar data coming into the Region Operations Control Center (ROCC). Managing the radar data more efficiently will enable the operators to realize the full operational capabilities of the new radars without overloading the ROCC Central Computer. As a result, the demonstration is designed to provide insight into the radar data management problems being experienced by the Alaska NORAD Region (ANR) and the ability of the ATS to solve them. Specifically, the ANR would like to determine the validity of the claims of the ATS's capabilities. For example: Can the ATS accurately discriminate true targets from clutter? From an air defense point of view, can the ATS provide target discrimination without target elimination?

The demonstration will select three sites, all equipped with ECPs. All of the ECPs will be turned off for the demonstration in order to reestablish the radars to a fully sensitized state. The ATS must prove that it is capable of handling the data workload from a fully sensitized radar.

The ATS will not be installed at the selected radars because of the logistics and prohibitive costs. Instead, the ATS equipment will be installed in the ROCC.

The ATS will be connected at the ROCC Communications Segment, the point where the data arrives in the ROCC via satellite from the selected radars. The data arriving at this point has not yet been processed by the ROCC central computer. Therefore, connecting the ATS at the ROCC Communications Segment simulates the ATS processing the data at the radar site.

The next step will be to compare the amount of data a fully sensitized radar forwards with the amount of data a fully sensitized radar equipped with an ATS forwards. The ROCC provides the

capability to simultaneously measure ATS and non-ATS data from the same site (see Figure 4)[Ref. 10]. The reduction in data, and the quality of the data must be analyzed simultaneously. The ATS may live up to its clutter reduction claims, but the data has to be analyzed to ensure that the ATS is not eliminating or erroneously manipulating valid air targets necessary for air defense and air training missions. In order to verify the target data, a specific number of aircraft, flying different profiles, will be used. The experiment will be designed to control the number of aircraft. However, the actual flight profiles along with the number of aircraft used during the test will only be known by a third party, disassociated from the experiment. Only after the experiment is completed and the analysis turned in will the aircraft portion of the experiment be revealed. The purpose of this single blind design is to eliminate any bias from the experimenters.

The anticipated results: Measurable differences between the quantity of data received from a radar in a fully sensitized state, when equipped with an ATS and when not, are expected. However, whether or not the ATS eliminates valid air targets remains to be seen.

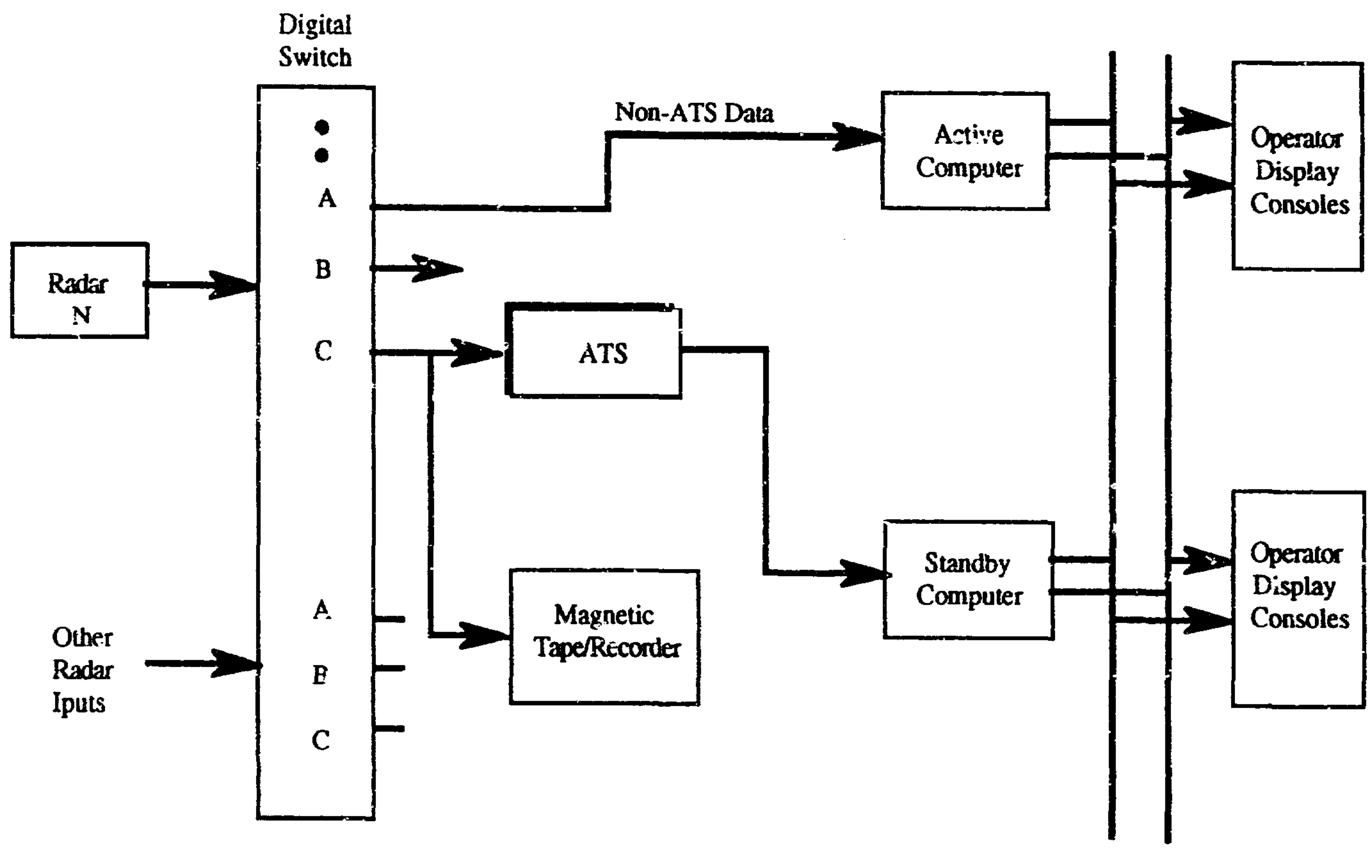


Figure 4 ROCC-ATS Interface

C. The scope of the demonstration:

This demonstration will provide the information the 11th AF Commander needs to decide whether or not the ATS (or other associated Radar Data Management System) provides viable solutions to the radar data management problems experienced by the ANR. There are several potential benefits if the ATS demonstration proves successful. First, ECPs can be eliminated from the radars, restoring them to their full operational capability, and providing greater low level detection of aircraft and missiles. In the area of training, the improved detection capability will increase the radar coverage in the low level training areas.

Benefits should also be seen in the ROCC central computer. Installing the ATS at the radar head will decentralize the computer processing. The ATS will discriminate between clutter and target data, dump the clutter data, and pass only the target data to the central computer for further processing. The main benefits to the central computer are reductions in the amount of processing required and the potential for a computer overload that arbitrarily dumps data.

The reduced computer workload will enable the installation of additional radars. This is important because PACAF wants to expand the air training ranges in Alaska. The eruption of Mount Pinatubo and subsequent loss of a major air training exercise in the Philippines called Cope Thunder required more training, and thus an expansion of the air training ranges, in Alaska. As a result, additional radars are needed to provide coverage in these new training areas. However, the additional data from these sites could easily create an overload condition in the computer. Dumping data during a major exercise would seriously jeopardize the safety of the entire mission.

The life of the central computer will be prolonged because the amount of data the central computer has to process will be

eased. Thus, the costly acquisition of a new generation ROCC computer can be delayed.

3. Mistakes (Experimental Design)

The details of the experimental design should be included in the plan. It should explain the experimental setup in detail, including the physical setup, who the test subjects or experimental units are, what special equipment is required, and give the trial schedule. The hypotheses that are to be examined should be stated specifically, as should any assumptions that will be made. The statistical design of the experiment should be explained, along with definitions of measures that will be employed and instrumentation that will be used to collect the data. Provisions should be made for testing the setup and design, and for the trials.

While the Introduction section of the Plan fails to provide the necessary focus for the experiment, the Experimental Design section suffers from a lack of detail. The closest the Plan comes to an experimental design is the Procedures Section, a subsection of the Demonstration Objectives.

The Procedures Section attempts to cover too many details in a single page of material. Of the five statements listed on page 4-2, only three can be considered procedures. These three statements, taken from the Plan, are quoted below:

> Three radar sites (Cape Romanzof, Kotzebue, and Tatalina) will be used to collect data to satisfy objectives one and two (reduce demands on the FYQ-93 ROCC central computer, and radar enhancement). These sites were chosen because they possess the latest clutter reducing software (i.e. ECP 175 and the Multiscan Detection Processing (MDP)). At different times each day, data will be collected from each site for a period of 105 minutes. Each fifteen minutes, within the data collection window, the radar will be placed into a different configuration (e.g. ECP 175 enabled and MDP disabled). Data will be collected via data reduction, later collated on the Site Data Sheets (figure 1) and analyzed.

Data will be collected using low level flights (if available) in the ACMI range. This data will be used to assess the ATS'ss ability to enhance the probability of detection (Pd) of the FPS -117 radar.

A tracking test will be used to meet the third demonstration objective (increase probability of detection by reducing human variability in the detection/tracking process). A operator will be selected at random and given an area of responsibility (AOR) to initiate and maintain track continuity on all tracks in the AOR. The operator will operate with and without the benefits of the ATS and all track histories will be recorded via data reduction. A comparison will be made of the data collected from the data reduction products to determine whether or not an operator will realize an increased probability of detection by reducing human variability in the detection/tracking process. Detailed instructions will be provided to each surveillance operator by the project coordinator--thus insuring a degree of procedural standardization.

These three statements seem to try to map back to the original objectives that were not clearly defined in the first place. But, the result is unsuccessful, and the reader is left confused as to the specific outcome the procedures are trying to accomplish. The lack of clearly defined objectives has an adverse effect on how the experiment is to be conducted. As a result, the reader comes away without a clear idea as to what problem the experiment is trying to solve.

Another problem is that there are no procedures describing how the objective of "Reducing the demands on the FYQ-93 ROCC central computer..." will be accomplished. Is this objective no longer important?

The arbitrary presentation of procedural details further illustrates a lack of focus in the Plan. Paragraph two states that three sites were selected based upon the installation of certain ECPs. Why does it matter which ECP is installed at each radar? Should not one of the main procedures of the experiment be to disable all of the clutter reducing ECPs? If this is the case, then it should not matter what kind of ECP is installed at the radar. The procedure suggests that the experiment is designed to compare the various ECPs located at different radar sites with the ATS. This procedure does not map back to any of the objectives.

To further illustrate the arbitrary nature of the procedures, paragraph two states that data will be collected for a period of 105 minutes, and that every 15 minutes the radar will change to a different ECP configuration. There is no explanation given why a 105 minute data collection period was chosen. Furthermore, manipulating the configuration of the ECPs is unnecessary. The details mentioned in paragraph two only distract and confuse the reader.

Finally, paragraph two mentions that data will be collected via data reduction and then analyzed. Several questions are not addressed. First, what kind of data is being collected? How will the researcher know if this data will provide answers to the research questions if it is not clear what the questions are? What will the data measure? How will the data be collected? The data will be collected by data reduction, what does that mean? What instrumentation will be required to collect this data? What is the plan for analyzing the data after it is collected? All of these questions, and more, need to be included as details in the design of the experiment.

Paragraph three states: "Data will be collected using low level flights (if available) in the ACMI range. This data will be used to assess the [ATS's] ability to enhance the probability of detection (Pd) of the FPS-117 radar." This is what the experiment is suppose to be about, but, no details are given as to how this will be carried out. The lack of detail makes the reader wonder whether or not the experiment will be conducted "on the fly."

Paragraph four is a procedure for another experiment that would determine whether or not the ATS will increase the probability of detection by reducing the human variability in the detection/tracking process. This procedure fails to define details of how the experiment will be executed. For example: the procedure states: "A[n] operator will be selected at random and given an area of

responsibility (AOR) to initiate and maintain track continuity on all tracks in the AOR." What will his performance be compared to? What kind of operator will be selected? Background information is required here because there are different types and capabilities of ROCC operators. Furthermore, how will the operators be selected; based upon what criteria? Again, the issue of what measures will be used are not addressed. How will the data be collected? What instrumentation will be used to collect the data? What is the plan for analyzing the data? How does this experiment provide the evidence necessary to determine the capabilities of the ATS? Does this experiment focus on the primary objective? Or, is this experiment an example of how an experiment can get off track because of a lack of clear objectives?

4. Solutions (Experimental Design)

The experimental design problems are solved by utilizing the concepts found in the model and the paradigm. According to the paradigm, "the Experimental Design is comprehensive but executable if it tests all the pertinent hypotheses with measurable data by a practical analysis plan." In order to accomplish this task, the model must be used. The revised Experimental Design section that follows applies both the model and the paradigm and is a direct extension of the revised Introduction section.

II. REVISED EXPERIMENTAL DESIGN

A. Setup:

1. Physical

The physical setup is the crux of the entire experiment. The demonstration would not be possible if not for the flexibility of the ROCC system. Figure 4 depicts the actual physical interface between the ROCC and the ATS equipment. The following is a discussion of the ROCC-ATS interface.

The digital switch provides the interconnection between the communication channels from the radar sites and the central computer. The radar data at the digital switch has not been processed by the ROCC computer. Each radar sends its data to the digital switch at the ROCC via three 2.4 kbps communications channels. These channels feed directly into three ports associated with each radar at the digital switch. Two ports, designated A and B, are normally interconnected with the primary and standby central computers. The third port, designated C, is available for recording data on a noninterference basis. This is the location of the ROCC-ATS interface. At the same time, the cable from port B of the Digital Switch to the central computer will be disconnected at the computer, and the output from the ATS will be connected to the standby computer at its input channel (Figure 4).

2. Factors:

There are three experimental factors: radar sites at three levels; Litton ATS at two levels; and analysis equipment at two levels. Three radar sites have been chosen: Kotzebue, Cape Romanzof, and Tatalina (Figure 2). The ATS radar processing hardware/software is either on or off. Finally, the equipment being used to analyze the data is either third party, Air Force approved, test and evaluation equipment or the Litton Data Systems analysis program associated with the ATS.

3. Special Equipment:

a. The ATS consists of all of the interface hardware as well as the software to conduct the data collection and analysis. All will be provided by Litton Data Systems.

b. A neutral third party will be involved to provide balance and legitimacy to the experiment. This third party (i.e., 84th Radar Evaluation Squadron) must conduct the experiment in parallel with Litton. They must interface at the same location, with the same site, and at the same time. They will collect the data, analyze it, and compare their results with Litton's experimental results.

Aircraft will be dedicated to fly certain profiles within the coverage limits of the selected radar.

4. Schedule of Trials:

The schedule of trials will not be formally addressed in this sample plan. The driving factor for the schedule of trials will be the availability of the aircraft needed to fly the flight profiles. Making up a schedule of trials does not provide sufficient lessons learned.

B. Hypotheses:

1a. There is no difference between the amount of data forwarded by the fully sensitized radar and the radar equipped with the ATS.

1b. The alternative: There is a difference between the amount of data forwarded by the fully sensitized radar and the radar equipped with the ATS.

2a. There is no difference between the number of targets reported by the ROCC computer combined with the fully sensitized radar and the radar equipped with an ATS.

2b. There is a difference between the number of targets reported by the ROCC computer combined with the fully sensitized radar and the radar equipped with an ATS.

3a. There is no difference between the third party analysis results and the Litton Data Systems analysis results.

3b. There is a difference between the third party analysis results and the Litton Data Systems analysis results.

The first two hypotheses deal with the issues of quantity and quality of the data the ATS produces. Does the ATS make a difference in the amount of data being sent back to the ROCC central computer? And, does the ATS discriminate targets from clutter without eliminating valid air targets?

The third hypothesis is designed to validate the Litton demonstration by determining whether or not the data is consistent with that from an established test and evaluation system. The 11th ACW staff must be sure that the ATS works as claimed and that the analysis tools that are part of the equipment package portray the data in an accurate manner.

C. Assumptions:

1. Litton's interface hardware is compatible with the ROCC equipment.

2. The software will provide the type of analysis needed to answer the research questions.

3. The weather patterns and clutter density at the three sites are representative of the (AOR) overall.

4. Both Litton and the third party Air Force evaluation equipment is capable of counting and keeping track of the number of targets received from the radar.

Note: This assumption is based on the claims of Litton that its software has the capability to compile this type of information [Ref. 3]. Additionally, since the ROCC computer, a 1970s version computer, has the capability to count the number of tracks in the system, and is certified, it is assumed that the evaluation equipment exists within the Air Force, or else the ROCC computer could not have been certified in the first place.

D. Statistical Design of Experiment

The experiment is a 3 X 2 X 2 factorial single blind experiment. This means that one factor has three levels and the other two factors each have two levels. The first factor has three levels because of the selection of three different radar sites. The radar sites associated with these levels are: Kotzebue, Cape Romanzof, and Tatalina. This factor corresponds to hypotheses one and two stated above. The processing equipment is the second factor. The two levels are whether or not the radar is utilizing the ATS. This factor also corresponds to hypotheses one and two. The third factor is analysis equipment. The two levels for this factor are the third party operationally approved equipment and the Litton analysis equipment. This factor corresponds to hypothesis number three. The purpose of designing a single blind experiment is to eliminate experimenter bias and to serve as a means to evaluate whether or not the ATS is eliminating valid air targets.

E. Measures

The experiment is designed to evaluate the data forwarded by the radar. The data will be collected and reduced into two categories. The first category deals with the quantity of data and the second deals with the quality of data (target elimination). The categories of data are listed below.

Category one: Quantity. The total amount of data processed and sent by the radar to the ROCC, measured in bits per second.

Category two: Quality. The total number of targets being sent by the radar to the ROCC, measured by the total number of targets being sent by the ROCC computer to the operator.

F. Instrumentation

The instrumentation is the equipment used by Litton and the third party Air Force evaluation team to collect and analyze the data.

G. Testing & Pilot Trials

Testing will be done to ensure the ATS and third party equipment can be connected to the ROCC digital switch. Additional testing will be done to ensure the commander that the experiment will not interfere with the daily operations of the ROCC.

After the interfaces are made, pilot trials will be run to ensure that the data being collected is the correct data to test the hypotheses. The researchers will use the pilot testing to practice the experimental procedures. For planning purposes, time should be allotted in the master schedule for the pilot testing.

5. Mistakes (Data Description)

A description of the data should also be included in the plan. This section of the plan should contain an example of the raw data, (the entire set of collected data should appear in an appendix) problems experienced with collecting the data should be addressed, and the data should be presented in an understandable and easy to read format (i.e., tables or spreadsheets). Any methods used to reduce the data, or other manipulations, should be explained.

The way the Plan describes the data is another contributing factor to its overall weakness. The Plan describes the data in a subsection entitled Data Products. The opening statement: "Data products required to ensure accurate

analysis." implies that the data collected will answer the research questions being asked. The analysis of the Experimental Design section revealed that the plan does not mention how the data will be collected. The lack of measures, coupled with the fact that no testing and pilot trials are called for in the plan, leads one to believe that no one would know if the wrong data had been collected until after the analysis had begun. This is too late to learn that the data collected will not answer the research questions.

Another problem with the Data Products section is that it states the data is to be collected from the Aircraft Combat Maneuvering and Instrumentation Center computer (ACMI) and the ROCC. However, there is no description of the data that will be collected from these two points. The Plan also mentions that a log will be maintained at the Air Surveillance Technician position. A log may be useful to help reconstruct the experiment, but it should be kept by a person directly involved with the experiment. Furthermore, a log of this nature does not provide any real data for analysis.

6. Solution (Data Description)

As with the other sections of the Plan, the revised Data Description Section that follows provides a possible solution based upon the lessons learned from the mistakes of the original plan and utilizing the model and paradigm.

III. REVISED DATA DESCRIPTION

Table 1 presents the data coding scheme. The table depicts the three factors (Radar Sites, Analysis Equipment, Processing Equipment) along with their associated levels. The number in parenthesis is the code assigned to the particular level. The coding scheme will become apparent when the table listing the different combinations of trials is presented below.

TABLE 1 DATA CODING SCHEME

Radar Sites	Analysis Equipment	Processing Equipment
Kotzebue (1)	Third Party (1)	Non ATS (1)
Cape Romanzoff (2)	Litton (2)	ATS (2)
Tatalina (3)		

The data is divided into two categories.

Data: Total amount of data received from the radar (X in bits per second)

Total number of tracks (Y)

The data is divided into two categories to aid in the analysis, but it will all be collected at once for each trial. The computer software of the evaluation equipment will reduce the data into the X and Y categories designated above.

Table 2 depicts the combinations of levels of the factors. There are twelve combinations of factor levels, found by multiplying one factor with three levels and two factors each with two levels. Each of the trials will be replicated thirty times in order to assume the data approximates a normal distribution.

TABLE 2 TRIALS

Trial #	Radar Sites	Analysis Equip.	Processing Equip.	Data (X)	Data (Y)
1	1	1	1		
2	1	1	2		
3	1	2	1		
4	1	2	2		
5	2	1	1		
6	2	1	2		
7	2	2	1		
8	2	2	2		
9	3	1	1		
10	3	1	2		
11	3	2	1		
12	3	2	2		

There are a several steps in the data collection process. The first step is to collect all of the data the radar is sending to the ROCC. The total amount of data will be used by the analysis to answer hypotheses one and three. Target counts will then be compiled using the software capabilities of the computers. The target counts will be used to answer hypothesis number two. Additionally, the target count data can be used to provide supplementary information concerning hypotheses numbers three.

7. Mistakes (Analysis Plan)

A good plan must state how the analysis will be performed (the details of the analysis belong in the report). The analysis plan must also state the statistical tests that will be used to analyze the data.

The Plan does not address how the data will be analyzed, only that once the data is collected it will be analyzed.

8. Solutions (Analysis Plan)

The analysis section is the final section of the revised plan. Like the sections before, the mistakes made in the original plan are overcome by using the model and the paradigm as a guide.

IV. REVISED ANALYSIS PLAN

Balanced Analysis of Variance (ANOVA) will be used to analyze the data. The results will determine the outcome of the hypotheses tests. As indicated in the data section, there are two parts to the plan. The first section will use the balanced ANOVA to analyze the total amount of data. Thirty replications of each of the twelve trials will be made. This will be done to provide normality. The second phase of the analysis will also use balanced ANOVA, this time to analyze the thirty replications of target counts.

B. REPORT ANALYSIS

The same analytical tools used to evaluate the ATS Plan will be used to analyze the Report. The analysis will compare the information in the Report to what should be included in a report based upon the model and the paradigm. As with the analysis of the Plan, mistakes are addressed and solutions are presented. However, a revised Report is not presented because data crucial to the analysis was not collected or is not available for analysis. Since the entire report revolves around the Analysis Section, and data is not available to be analyzed, merely restating what has already been said in the revised Plan and leaving the Analysis Section out would have little value.

The formal title of the original report is: <u>LRR ENHANCEMENTS STAFF STUDY</u>. This is the final report to the 11th Air Force Commander recommending a course of action based upon the outcome of the RDMS demonstrations. It is

interesting to note that only one demonstration plan but two demonstrations are addressed in the final report.

Two demonstrations were conducted by the 11 ACW. First, Litton Data Systems demonstrated the Advanced Tracking System (ATS). The planning for this demonstration took an entire year and culminated in the execution of the ATS Demonstration Plan. After the ATS demonstration and analysis were complete, Sensis Corporation hearing that their competitor Litton Data Systems had conducted a demonstration in Alaska, contacted the 11 ACW expressing their desire to demonstrate their equipment. The 11 ACW, concerned with the legal consequences of not letting Sensis Corporation demonstrate their equipment, allowed a Sensis demonstration. Because of the short time interval between the Litton and Sensis demonstrations, a plan could not be written, approved, and disseminated. As result, a Sensis Plan does not exist. The Report is the first time the Sensis demonstration is mentioned.

1. Mistakes (Introduction)

An Introduction Section of an experimental report is similar to that already discussed for an experimental plan. This section should introduce the researchers involved with the experiment, contain a well defined purpose, including a statement of the real world problem and specific questions the experiment seeks to answer, the experimental approach, and anticipated results, as well as the scope of the experiment. In addition, the Introduction Section of the report should also contain any additional information that may have occurred during the course of the experiment.

The Report fails the same the way the Plan fails. It does not meet the requirements of either the model or the paradigm. The Report does not contain a clearly defined Introduction Section. The analysis of the Plan demonstrated that

if the Introduction Section failed to state a clear objective the rest of the Plan suffered because it is too easy to get side tracked from the original purpose of the experiment.

There is one overarching problem with the Report. There is a shift in the emphasis from what the Plan set out to accomplish and what the Report is trying to accomplish. The first sentence in the Report reveals the discontinuity between the Plan and the Report. The first sentence states: "The 11th AF needs to acquire a system that will integrate existing systems i.e., 3DS [Digital Data Display System], AICU [Advanced Interface Control Unit], and ACMI [Air Combat Maneuvering and Instrumentation], into a cohesive, efficient system providing unseen benefits to the Alaska 2000+ Range Improvements Project" (see Glossary, Appendix A, for definition of terms). Remember, the Plan was to focus on validating the claims of Litton Data Systems Advanced Tracking System capabilities. However, the first statement in the Report clearly indicates a shift to a different emphasis.

The next area the Report addresses is: Factors Bearing on the Problem. The first factor (paragraph a) states the requirement for integrating another type of radar into the ROCC. This is valid requirement. However, isn't this requirement a benefit? If the Plan and the execution of the experiment had focused on validating the ATS's capabilities, and the report presented evidence to support these capabilities, then the RDMS could be considered a viable solution. The next three factors, also taken from this section, address integration issues (paragraph b,c,and d) and appear below.

> b. Currently, no capability exists to automatically insert flight data on military aircraft into 3DS. The NORAD Software Support Facility (NSSF) is working on CSCP [Computer Software Change

Proposal] # 4569 which would allow the automatic tell of military aircraft. Hence, creating the pathway needed to get data on military aircraft into 3DS. The solution the NSSF is trying to achieve is a major software change: no solution is on the horizon.

c. Track data on aircraft not equipped with ACMI pods, but still players in large force exercises (LFEs), are not entered into the ACMI.

d. Radar data on aircraft not equipped with ACMI pods are detected by LRRs surrounding the range; however, this information is only sent to the ROCC. The idea here is to provide data on exercise participants, not capable of being tracked by ACMI, to the ACMI via the LRR-ROCC/AICU-ACMI interface (see attach. 1). The results: a more complete, accurate air picture, providing an added measure of flight safety both to the military and civil sectors.

The statements that there exists an inability to automatically insert flight plan data as well as track data on aircraft not equipped with ACMI pods into the 3DS is an attempt by the 11 ACW to provide evidence to support the RDMS as a solution. A requirement to automatically fuse data derived from outside C3 systems may exist, but the experiment was not designed to support this question. Furthermore, no evidence exits in the Report to support this requirement.

The integration issues also address the important safety role the radars play in keeping track of aircraft not equipped with ACMI pods. Aircraft not equipped with ACMI pods are not tracked by the ACMI and the radars provide the only measure of safety. While this is true, and there is a requirement to integrate this data, the report claims an added measure of safety it can not support with data obtained by the experiment. The experiment was not designed to support a flight safety issue. Therefore, conclusions about flight safety can not be extrapolated from the experiment that was conducted.

The next factor addressed (paragraph e) is the communications interface between the ROCC and the radar.

> e. The communication interface between the LRR and the ROCC needs to be made more efficient. At present massive amounts of radar data, most of it useless clutter is being bulk encrypted and sent over the communications circuits to the ROCC (see attach. 2). Sending only true target information, filtered from the clutter, will reduce the burden on the interface, thereby making this interface more efficient.

Again, this a valid requirement, but one that is not addressed by the current Plan. In order to make any claims about how much burden would be reduced by an RDMS, experiments have to be designed with this question in mind.

The report states (paragraph f) that one of the factors is: "Too much useless data is being sent to the ROCC computer for processing. Sending only data which contains true target information will inherently make the ROCC computer more efficient." How can this statement be verified from the design of the experiment put forth in the Plan? Again, a separate experiment must be conducted if the 11 ACW wants to verify these claims.

Human variability is addressed in paragraph (g). The Report says: "A human variability in the target detection and tracking process exits. " There is no denying that variability exists between individuals in the tracking process. Furthermore, it would seem likely that if the RDMS lived up to its capability the variability in the tracking process could be reduced. However, the Report sites one of its attachments (see attachment 3 in Appendix D) as supporting evidence to this claim. This attachment is a view graph of a radar scope demonstrating the difference in the amount of data between an ATS equipped radar and a non-ATS

equipped radar as seen from an operator perspective. This view graph does not, however, support the claim that variability in the tracking process can be reduced. Visually looking at the differences does not tell the whole story. The view graph does not provide insight as to how the data is being processed by the ATS or whether the ATS is eliminating targets of interest (the primary objective of the Plan). A statistical analysis of the raw data needs to be accomplished according to a design like that laid out in the new Plan.

The final factor the Report mentions is the need to integrate all of the stovepipe C2 systems in the theater (paragraph h). The reports says: "Systems, i.e., AICU, ACMI, CTIS [Commander's Theater Information System]/3DS, need to be integrated more efficiently. Information available to one system can be made available to another system. For example: track data the AICU receives from an LRR can be made available to both 3DS and ACMI." Again, this is clear evidence of the shift in emphasis between the Plan and the Report. The emphasis has shifted from validating the ATS's capabilities to using the Range Improvements Project requirements as a means of justifying the procurement of the RDMS.

The fifth and final section of the Report is the Discussion Section. The material mentioned in this section could either be totally eliminated from the report or included as part of the Introduction Section, providing background.

The general impression of the Discussion Section is that the RDMS is the "catch all" single solution to all of the Range Improvements Project's requirements. The introduction paragraph states: "A solution will be offered, tested against criteria, and shown how this solution will solve the problem." The report argues that if the RDMS can hold up to the scrutiny of criteria that are

established for the first time in the Report, then the RDMS must be the a valid solution.

The entire discussion appears to be a sales pitch to the decision makers on the importance of the RDMS to the Range Improvements Project. The Report essentially ignores the original purpose of the demonstration, as stated in the Plan or otherwise, and argues that the RDMS is the only solution because it meets all of the criteria the Report established. The Discussion Section makes no attempt to address the issue of whether or not the claims made by the vendors about their equipment are valid. The only things offered are excerpts from the contractors final reports on how great their equipment is and all the reasons the 11th AF should buy their equipment. There is no independent, unbiased, scientific analysis of the data. The only analysis is from the vendors, using their equipment and their analysis tools.

The 11th ACW is asked to have faith that the analysis conducted by the vendors, using their own equipment, is reliable. The demonstration started out with the stated purpose of determining the validity of the ATS's capabilities and ended up using the ATS as a solution to an integration problem. This drift can be traced back to the lack of focus of the Plan, which did not provide a "road map" that the 11th ACW staff could follow. This lack of focus lead to a Plan and Report that lacked credibility and do not provide concrete answers for decision makers. This is probably why the PACAF has yet to acquire a RDMS for the Alaskan radars.

2. Solution (Introduction)

The Introduction section in the final report provides information to the reader of the report who has not read or had access to the Plan. Therefore, everything mentioned in the Introduction Section of the revised Plan should be

included in the final report, plus any additional information revealed during the experiment.

During the time of the demonstrations, the Alaska 2000+ Range Improvements Project became a prime interest of the 11th AF commander. The 11th ACW saw the Range Improvements Project as a funding vehicle for their RDMS project. The background politics explain the discontinuity between the Report and the Plan; however, this is not an excuse for allowing a shift in the problem emphasis. The RDMS project can only suffer. When the focus shifts back to the RDMS, questions will be asked about the validity of its claimed capabilities. If both the Plan and Report focused on the questions of validating RDMS capabilities, then the 11th ACW would have strong supporting evidence for piggybacking on the Range Improvements Project.

3. Mistakes (Experimental Design)

Like the Introduction Section, the Experimental Design Section shares similarities between the experimental plan and report; the difference is that greater detail must be included in the report. It should explain the experimental setup including the physical setup, who the test subjects or experimental units are, what special equipment is required, and give the trial schedule. The hypotheses that are to be examined should be stated specifically, as should any assumptions that will be made. The statistical design of the experiment should be explained, along with definitions of measures that will be employed and instrumentation that will be used to collect the data. Provisions should be made for testing the setup and design, and for the trials.

The Report fails to adequately address the experimental design. The report contains Assumptions and Criteria Sections that could be considered elements of the experimental design section. The assumptions deal only with

integration. The assumptions are: "Industry has the capability to solve the integration requirements we have established during this study. The AICU will be able to receive track messages from the RDMS and route these messages back and forth between the 3DS and ACMI." However, assumptions used to analyze the data collected from the experiment are not mentioned.

The Criteria Section deals only with requirements that have to be met in order to provide an adequate solution to the interface problems. Each of the five criteria are biased towards the RDMS as a solution. The report lists the following as criteria:

a. The solution must be able to reduce the burden on the LRR-ROCC interface.

b. The data that's being output is in a format that can be used by the ROCC computer as well as the AICU.

c. The solution must be able to integrate and interface the AN/TPS-63 radar data in the correct format into the ROCC where it will be routed via the AICU to the 3DS and ACMI.

d. The system must have an open architecture design, being able to be incorporated into future systems (ROMS/RAMMS).

e. Versatile user friendly workstations, providing self diagnostics and real time radar status monitoring, as well as GCI control.

Clearly each of the criteria takes advantage of the proposed benefits touted by the vendors of the RDMS equipment. Once again, the political pressures are at work: If the RDMS could meet all of the criteria, how could the decision makers ignore the RDMS and not allow funding to a system that directly impacts the Range Improvements Project?

4. Solutions (Experimental Design)

The report should address the experimental design in same manner as the Plan. The experimental design section tells the reader how the experiment was carried out. No details should be left out. The report must provide details

concerning the setup of the experiment, hypotheses must be clearly stated (these are the specific research questions), assumptions made must be listed, the statistical design of the experiment must be presented, the issue of what kind of data was collected, and how it is to be collected, must not be overlooked, and testing and pilot trials have to be mentioned.

5. Mistakes (Data Description)

This section of the plan should contain an example of the raw data, (the entire set of collected data should appear in an appendix) problems experienced with collecting the data should be addressed, and the data should be presented in an understandable and easy to read format (i.e., tables or spreadsheets). Any methods used to reduce the data, or other manipulations, should be explained.

The Report does not even mention the data. There is little doubt as to why the incorrect data was collected because neither the Plan nor the Report was concerned about data collection.

6. Solution (Data Description)

All of the details described in the revised Plan need to be included in the final report. As a matter of fact, the report should contain even more detail than the plan. The report should contain an example of the raw data, and problems the data should be addressed. All of the data collected should be presented in an appendix or in an archive.

Readers may want to replicate the experiment to verify the results claimed in the report. The data coding scheme (an example appears in the revised Plan) must be included. This will allow the reader to decipher the way the experimenter coded the data, and it will aid in understanding the analysis. If possible, and for the sake of clarity, the data should be presented in a tabular form. If the data is manipulated or reduced in any way, this has to be addressed.

The bottom line: The data description must be detailed and accurate enough so that the experiment can be replicated and the results verified.

7. Mistakes (Analysis)

The Analysis section is probably the most important section of the report. This section should contain a summary of the analysis plan that was presented in the experimental plan, a detailed methodology of how the analysis was conducted, the results of the analysis, and any additional assumptions that were required.

The Report lacks any significant analysis section. No statistical analysis of the data is accomplished. The view graph attachments at the end of the report (see Appendix D) are the only things presented as the analysis. Basically, the 11 ACW presented the findings of the vendors. No attempt was made, nor was any data provided, to verify the claims made by the vendors. The problems with the analysis stem all the way back to the lack of focus and clearly defined objectives in the Plan and the resulting inability to maintain focus from the inception of the Plan through its execution.

8. Solution (Analysis)

Data that can provide the answers to specific research questions, generated from well defined objectives, is a key piece of the solution to the analysis failure. There are several elements that are essential to the analysis section. The analysis should contain a summary of the analysis plan presented in the initial experiment plan. The methodology used to collect the data and how that data was analyzed must be detailed, and any additional assumptions that the experimenter made have to be addressed. The results of the analysis are the heart of the entire experimental process. They results allow conclusions to be drawn

and recommendations to be made that are objectively based on actual experimental outcomes.

9. **Mistakes (Conclusions)**

The Conclusion Section is unique in that it only appears in the experimental report. This section presents the results of the hypotheses that were listed in the plan, as well as any other interpretations drawn from the analysis of the data. These results are then related to the real world problem the experiment set out to answer. An overall summary of the experiment should also be presented in this section.

The Report states: "... demonstrations conducted by Litton Data Systems, Sensis Corp., and GE Syracuse, have clearly shown that industry possess the capability to meet our established criteria. A RDMS at the LRR would integrate radar data from both the AN/FPS-117 and AN/TPS-63 [the proposed Westinghouse radar that would be acquired to enhance radar coverage in the expanded training areas] radars into the ROCC, 3DS, and ACMI while at the same time increasing the efficiency of the entire Alaska 2000+ Range network." First, the 11 ACW had little or no involvement with the GE demonstration, so it will not be addressed in this analysis. Second, the motivation behind the report was to show how the RDMS equipment could be used to integrate the various in-theater C2 systems. Clearly a different objective than what was initially proposed: To verify the claims made by the vendors about their equipment capabilities. Since the report argues for the integration benefits of the RDMS equipment, the analysis presented in the attachments is arguing in favor of the capabilities. In short, the conclusions are not valid. There is no evidence to support the conclusions being drawn.

10. Solution (Conclusions)

The main ingredient to solving the problem with the conclusions is maintaining a constant focus on the objectives of the experiment throughout the Plan and Report. One approach to achieving this focus is the use of the model and paradigm. The model contains four elements in the Conclusion Section. The first element is the hypotheses results, along with the interpretations of these results. The second element is any other interpretations. Third, and probably the most important, the real world meaning of the results. Finally, an experimental summary should be drawn. According to the paradigm, the conclusions are "...supportable if they are valid results of an analysis that follows logically from the study."

11. Mistakes (Recommendations)

The report should finish with a Recommendations Section. This section should contain a discussion of potential changes to the experiment along with recommendations for further work in this area.

The Report does not contain the elements described above, instead the Report makes a recommendation in favor of the RDMS. Based upon all of the analysis of this Report, there is no evidence to support this recommendation.

12. Solutions (Recommendations)

The Recommendations Section of the report, in addition to offering recommendations, should contain sections dealing with changes to be made to the experiment. Additionally, the recommendations section should address any requirement for further work in this area.

13. General Issues

Finally, there are two general issues concerning the overall quality of the experiment. First, is the issue of simplicity. According to the paradigm, the report

is "...simple if it is short and illustrative, has a minimum number of assumptions, alternatives, hypotheses, and measures, plus easily understood analysis and conclusions." The Report fails to meet the definition of simplicity. While it is short, the Report fails to illustrate how the experiment was carried out. The assumptions are not representative of an experiment initially designed to verify the capabilities of the ATS. Instead of listing specific hypotheses, integration criteria are listed. Neither measures or an analysis is addressed by the plan. A marginal attempt at an analysis is made using view graphs. Finally, the conclusions stated apply to benefits of integration and not about RDMS capabilities.

The second issue addresses the consistency of the report. "The study is consistent if there is compatibility in scope and detail at each step. In addition, direct linkage between the steps must maintain continuity with the objective." The shift in the objectives between the Plan and Report is evidence the study is not consistent. There is no continuity between the Plan and the Report.

C. CONCLUSIONS

The ATS Demonstration Plan was analyzed using the Experiment Plan and Report Formats as a model of how a plan is organized. The Evaluation of Studies paradigm provided definition to the organizational model. Highlighting the mistakes of the Plan was only part of the analysis. The next step was to take the lessons learned from the Plan and apply them to a new hypothetical plan.

The analysis of the Report (known as the LRR STAFF STUDY) focused on the analysis and recommendations. Like the analysis of the Plan, the Report analysis utilized the model and paradigm as evaluation tools. The Plan and Report are similar because most of the material covered in the Plan is summarized in the Report. Unlike the analysis of the Plan, the analysis of the Report does not

provide a new Report because data is missing from both Litton and Sensis. The missing data can not simply be made up in order to complete an analysis consistent with the new Plan.

The analysis reveals many mistakes in both the Plan and Report. However, many lessons can be learned from this experience. These lessons have been applied in the creation of a new Plan. Furthermore, generic lessons, applicable to experiments and experimenters, are found in Chapter IV.

IV. LESSSONS LEARNED

Specific lessons can be learned by studying the Plan and Report described in this thesis. The analysis chapter illustrated many mistakes that can be made during an experiment. This chapter takes the specific mistakes made during the RDMS experiments and creates a list of lessons learned. Additionally, the lessons the author (who was a major player in the original experiment) learned are listed and are applicable to experiments in general Hopefully, these lessons learned may serve as a guide to staff officers that have little experience in conducting experiments but are tasked to conduct an experiment in an operational environment.

A. SPECIFIC LESSONS LEARNED

Experimental plans and reports have specific roles. The plan describes in detail how the experiment will be executed. The report describes the execution of the experiment, providing an analysis, drawing conclusions and making recommendations. The lessons described in this section all relate to specific mistakes identified in the Plan and the Report.

1. Clearly Defined Objectives

Clearly defined objectives are a must. They provide the foundation upon which the entire experiment is based. For example, the objectives defined in the experimental plan provide the focus for the entire experiment. Without this focus the researchers may find it very difficult, if not impossible, to carry out a successful experiment.

2. State the Purpose

State the purpose of the experiment, preferably in an Introduction Section, both in the plan and in the final report. The purpose should describe the real world problem the experiment is trying to solve along with specific questions the experiment seeks to answer. This is important because it helps to maintain the focus for the experiment. After this groundwork is laid, a description of the approach the researchers will use to try and solve the problem must be addressed. Finally, to help build a common mental picture of what the experiment hopes to achieve, there should be a statement about the anticipated results of the experiment.

3. Define the Scope of the Experiment

The importance of this experiment, why the experiment is being conducted, and what impact will it have, constraints placed on the conduct of the experiment, and boundaries on the applicability of the results, should be spelled out in a section that describes the scope of the experiment.

4. Provide a Detailed Experimental Design

The experimental design is the heart of the plan. This section should provide the details of how the experiment is to be executed. It should be detailed enough so that when the experiment is verified it can be replicated.

5. Provide a Data Description

What kind of data is going to be collected and used for analysis? Will an analysis of the data provide answers to the questions being asked? These questions must be answered prior to the start of the actual experimental trials. The researcher must know what kind of data is being collected and whether or not it will be useful.

6. Prepare an Analysis Plan

After the data is collected, it must be analyzed. To prevent bias in the analysis, and to ensure that the right data is collected, the researcher must have a plan of how the data will be analyzed. While the analysis plan is stated in the experimental plan, the actual analysis and results are the crux of the final report.

7. Conduct Testing and Pilot Trials

A preferred method of determining whether or not the correct data will be collected during the experiment is by conducting testing and pilot trials prior to the actual execution of the experiment. Testing and pilot trials prior to the start of the 11^{th} ACW experiments would have determined that the data being collected was incomplete and would not adequately provide for an analysis that would yield insights as to the capabilities of the RDMSs.

8. State Supportable Conclusions

The results of the analysis should answer the specific questions being asked. The conclusions must be supported by the results of the analysis.

9. Make Sound Recommendations Based Upon Analysis of the Data

The recommendations that are made should be supported by data collected through the execution of the experiment and not by circumstantial evidence.

B. GENERALIZED LESSONS LEARNED

The generalized lessons learned are subjective lessons the author developed during the course of this thesis. These lessons, hopefully, will serve as a guide to those staff officers with little background in experimentation, but are nonetheless called upon to conduct experiments in an operational environment.

1. Ask Questions

Can experiments be conducted in an operational environment? What will the operational impact be if the experiment is conducted? Will the operational mission adversely affect the experiment? Will experiments conducted in the operational arena yield useful results? Should commander involve the staff to conduct these experiments? Is the staff knowledgeable enough to undertake this task? Or will outside assistance be required?

2. Gather Knowledge Base

Ensure knowledge exits within the staff to conduct such an experiment. If necessary seek help from other sources. Maybe even have some other unit or agency come in and conduct the experiment. This will alleviate any bias the home staff may have towards the experiment. Two views existed: one favoring the ATS equipment, and one wanting no part of the equipment. Interestingly, the lines of opposing opinions were drawn between operations and maintenance staffs. The operations staff wanted to see the ATS equipment incorporated while the maintenance staff wanted to continue on with the current ECP fixes.

3. Be Open Minded, Yet Remain Cynical

Don't get locked into one solution and fail to seek other viable options. Be cynical, ask hard questions. Don't be impressed with "bells and whistles." Seek proof of claims from independent sources.

4. A Good Plan is a Must

A good plan must have clearly defined objectives. These objectives are then broken down into questions the plan will be designed to answer.

5. Keep Research Questions Simple

Keep research questions simple and in line with operational constraints. Trying to solve complicated research questions in a constrained operational environment may prove to be too difficult and best left to the laboratory. Break the complicated research question down into smaller pieces.

6. Pilot Trials are Essential

Pilot trials ensure the data collected will provide answers to the questions being asked. Ensure the data is replaceable.

7. Keep Detailed Notes

Trying to remember of the details of an experiment is an impossible task unless detailed notes are kept.

8. Do Not be Afraid to Modify the Experiment

If the pilot trials indicate flaws with the experiment, change whatever you need to change. Objectives may have to be modified. Whatever the case, do not be afraid to admit mistakes. The important thing is to correct the mistakes before the actual trials begin. Time and money are precious commodities. If mistakes remain undiscovered or overlooked, rerunning the entire experiment may not be feasible.

9. Use the Right Statistical Tool for the Right Job

Using certain statistical tools requires different assumptions to be made. Using the wrong tool seriously undermines the conclusions drawn from the analysis.

10. Report Results in a Clear, Concise, and Simple Format

Do not attempt to give a technical brief to a commander and his staff. You could quickly find yourself out in the hall. If, by chance you are allowed to

proceed, you run the risk of creating a great deal of confusion and seriously jeopardizing an credibility of your office.

11. Present Only the Facts, Don't Speculate

When asked to report the results of your analysis report only the results. If you do not have the answer say so and do not interject personal opinions. Doing so only clouds the results of the experiment.

12. Be Careful About Extrapolating Results to Other Situations

This lesson is a corollary of the above lesson. There is an overwhelming urge to extrapolate the results of experiments to other areas of interest. Care must be taken. The results of the experiment are for a certain set of conditions. Extrapolating results of an experiment to a different set of conditions without further research is not wise. In other words, stay within the scope of the experiment.

13. Ensure Consistency Between the Plan and the Report

The conclusions presented in the final report should be consistent with the primary objective stated originally in the plan. If, for some reason the objectives of the experiment change, then the plan should reflect the changes prior to conducting the experiment.

V. CONCLUSIONS

The data collected could not provide the answers to the primary questions, and that analysis of the Plan and Report revealed several weaknesses which no doubt contributed to this failure. A summary of the deficiencies is given in the following paragraphs.

The overarching problem with the Plan was that it failed to clearly define the objectives of the experiment. This resulted in a lack of a clearly defined purpose. As a result, the Plan constantly strayed from the primary objective: verifying the ATS's capabilities.

The Plan also failed to provide a detailed description of the experimental design. As it is presented, the Plan does not describe how the experiment will be conducted to verify the ATS's capabilities. This resulted in procedures calling for experiments that did not relate to the primary objective.

The lack of a clearly defined data description resulted in an inability to conduct a thorough analysis. The Plan states that data will be collected and then analyzed. However, there is no description of the data, how it will be collected, or any testing done to determine whether or not the data is the correct data needed for the analysis. The analysis could not be conducted because insufficient data was collected.

The Plan also lacks an analysis section. There is no mention as to how the data will be analyzed. The result is seen in the Report where the analysis uses subjective arguments to support certain criteria and view graphs showing the benefits in reducing the amount of data being sent by the radars.

The lack of clear objectives also plagued the Report. As a result, the entire emphasis of the Report shifted from verifying RDMS equipment capabilities to integrating other in-theater C3 systems.

The Report lacked any significant analysis. Instead of analyzing collected data to test the validity of the ATS, a set of criteria, not previously discussed, was presented. The analysis consisted of examining whether or not the RDMS equipment would meet the criteria. As a result, little if any, information could be gleaned from the analysis.

The conclusions presented in the Report were not supported by a statistical analysis from data collected during the experiment. Instead, the Report presents view graphs providing a visual representation of the RDMS equipment capabilities. The result is that there are still questions about the validity of the RDMS and its capabilities. The conclusions seemed to be based upon circumstantial evidence not on evidence provided by the analysis data collected during the experiment.

The final result of the Plan and Report is a positive endorsement of the RDMS as a solution to the radar data management problems found in Alaska. However, based upon the analysis, the recommendations made in the Report are of doubtful validity.

The model used in this thesis is an accepted evaluation tool. There is no requirement that all experimental plans and reports follow this model; but, it is the opinion of this author that the Plan and Report failed partly as a result of not following a model such as the one taught at the Naval Postgraduate School.

VI. SUMMARY AND RECOMMENDATIONS

The purpose of this thesis was to analyze an actual experimental plan and report and provide lessons learned. The entire experimental process, starting with the plan development and proceeding through the publication of the final report, lasted approximately two years. The motivation behind this thesis was to illustrate the difficulties involved with experimentation. Compounding these difficulties is the fact that this author, who was in charge of the experiment, lacked the proper training needed to carry out an experiment successfully. However, after attending the Naval Postgraduate School (NPS) and studying the correct way to conduct an experiment, this author decided to use the lessons learned at NPS to analyze what was done two years before.

Chapter II provided background stating the motivating factors behind the experiment. Chapter III is the heart of the thesis. This chapter analyzed the ATS Demonstration Plan and the LRR Enhancements Staff Study. Mistakes were pointed out and solutions were offered based upon the Experiment Plan and Report Format as well as the Evaluation of Studies paradigm presented in the Joint Command and Control and Communications curriculum offered at the Naval Postgraduate School. Chapter IV provided the lessons learned from the experiment. The purpose of this chapter was to provide a guide to those staff officers who have little experience in experimental design and analysis but are nonetheless tasked to conduct an experiment in an operational environment. Hopefully, the lessons learned may serve as a guide so that these staff officers can provide reliable recommendations to decision makers.

Further work needs to be done to determine the validity of the RDMS. Experiments need to be conducted that determine whether or not the RDMS

device is eliminating data on targets vital to air defense and air combat training. After this is determined, questions of integrating this system into current C3 architectures can be addressed.

LIST OF REFERENCES

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2. *RADAR DATA FLOW HANDOUT,* 11 TCG DOCT, March 1986.

3. *MINIMALLY ATTENDED RADAR*, Phase II/ASO: MAR/085, pp. 1-3, 11 TCG DOCT, 25 June 1985.

4. *ROCC Computer Diagram,* 11 TCG DOCT, March 1986.

5. *AN/GYQ-51 ADVANCED TRACKING SYSTEM(ATS) TECHNICAL DESCRIPTION,* pp. 1-1 - 1-11, Litton Data Systems, Van Nuys, California, 25 April 1988.

6. *MULTI-SCAN CORRELATOR MODEL-2000 (MSC-2000) PRODUCT DESCRIPTION,* pp. 1-15, Sensis Corporation, DeWitt, New York.

7. *ADVANCED TRACKING SYSTEM DEMONSTRATION PLAN,* 11th TACTICAL CONTROL WING (PACAF), Elmendorf AFB, AK, 1October 1991

8. *LRR ENHANCEMENTS STAFF STUDY,* 11th TACTICAL CONTROL WING (PACAF), Elmendorf AFB, AK, 28 FEBRUARY 1992.

9. *Experiment Plan and Reports Format and Evalution of Studies Paradigm,* CC4003 Class notes, Naval Postgraduate School, Dr Michael Sovereign, Dr. William Kemple, 5 January 1994.

10. *SENSIS CORPORATION MULTI-SCAN CORRELATOR-2000 DEMONSTRATION REPORT,* pp. 1-31, Sensis Corporation, DeWitt, New York, December, 1991.

APPENDIX A

GLOSSARY

ACMI

ACMI stands for Aircraft Combat Maneuvering and Instrumentation. The ACMI was initially designed as a training device for fighter pilots. The ACMI provides a three dimensional view of aircraft in relation to its environment providing lessons learned for mistakes made in flight.

AICU

AICU stands for Advanced Interface Control Unit. This system is designed as a translator and router of data. The purpose of the AICU is to serve as a main point where data from different sensors can be interchanged. Data from different sensors utilizing one type of protocol can be exchanged with data of other sensors utilizing a different protocol. For example, data from a Radar Management device located at a radar can be sent to the AICU translated into an appropriate protocol so the data can be displayed on the 3DS as well as on the radar consoles of the ROCC.

CTIS/3DS

CTIS/3DS stands for Commander's Theater Information System/Digital Data Display System. CTIS is a network of computers designed to collect and fuse data. The fused data is then displayed using a large screen display. The computer hardware and software required to project the fused data is called the Digital Data Display Device (3DS).

GCI

Ground Control Intercept. Air weapons control officers station in a ground based radar unit with the task of controlling aircraft.

LRR

Long range radars. In Alaska the LRR is the AN/FPS-117 Minimally Attended Radar.

Plot

Data necessary to describe a point in space. A two dimensional view (X and Y axes)

Target

Consists of more than one plot. Gives the third dimension. Associated data: Heading, Speed, Altitude. A direction can be determined from a series of plots called a target.

Track

A track is a target with alphanumeric data (symbology) attached. The symbology can either be manually or computer derived. Tracks are established by a radar operator who determines whether or not a target represents a valid aircraft. The operator has a direct involvement in the decision making process.

ROMS/RAMMS

Remote operational maintenance system designed to provide long distance status monitoring of the radar.

APPENDIX B

ADVANCED TRACKING SYSTEM DEMONSTRATION PLAN

11th TACTICAL CONTROL WING (PACAF)
ELMENDORF AFB AK 99506-2270
1 October 1991

ADVANCED TRACKING SYSTEM DEMONSTRATION PLAN

PACIFIC AIR FORCES
11TH TACTICAL CONTROL WING
ELMENDORF AFB ALASKA 99506-2270

FROM: 11 TCW/DO
6900 9th ST STE 301
ELMENDORF AFB AK 99506-2270

SUBJECT: Advanced Tracking System Demonstration Plan

TO: SEE DISTRIBUTION

1. Forwarded herewith is the Advanced Tracking System Demonstration Plan, 1 Oct 91. This demonstration is being conducted at the direction of 11 AF/CC.

2. This plan outlines those actions necessary to demonstrate the capabilities and utility of the Advanced Tracking System in the Alaskan Theater.

3. This plan is designed to demonstrate the operational capabilities of the Advanced Tracking System as part of the current Alaskan Surveillance and Command and Control System. Of particular interest will be the Automatic Tracking System's ability to reduce demands on the ROCC's central computer (processing time and memory space), restore the FPS-117, Long Range Radar, performance to its original operational specifications for target detection, and to reduce human variability in the detection and tracking process. The demonstration will take place from 7 Oct 91 to 18 Oct 91. The equipment will be located in the ROCC in order to take advantage of the existing communications circuits feeding radar data from the Long Range Radars (LRRs) to the ROCC computer. Locating the ATS in the ROCC will allow access to any radar without the logistics of transporting people and equipment to remote sites and make the equipment available for maximum visibility.

GEORGE A. PAHLS, Colonel, USAF
Deputy Commander for Operations

1 Atch
Advanced Tracking System
Demonstration Plan

PLAN SUMMARY

1. PURPOSE: To outline responsibilities and procedures for the Advanced Tracking System Demonstration of 7 Oct-18 Oct 91.

2. CONDITIONS FOR IMPLEMENTATION: This project plan will be the basis of the Advanced Tracking System Demonstration. It will be implemented at the direction of the 11 TCW/DO.

3. OPERATIONS TO BE CONDUCTED:

a. Forces Assigned. All tasked units will respond when this plan is executed unless specifically excused by the implementing authority.

b. Supporting Plans. Not required.

4. OPERATIONS SECURITY (OPSEC): In the execution of this plan, OPSEC must be a matter of continuing concern in order to minimize disclosure of sensitive information. Since operations may reveal limitations of the Automatic Tracking System, the AN/FPS-117 Long Range Radar, and the ROCC AN/FYQ-93 computer, activity must be conducted so as to preclude inadvertent disclosure of sensitive and/or classified information.

5. COMMAND RELATIONSHIPS: Normal.

6. LOGISTICAL APPRAISAL: All logistical matters envisioned are feasible.

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PURPOSE

1. The stated purpose of the demonstration is determine whether or not the ATS can be used in the Alaskan Theater to improve radar performance and make recommendations concerning the desirability of incorporation the ATS in the Alaskan Surveillance and Command and Control System. The primary objective is to collect sufficient data to determine the ATS' capability for substantially improving the probability of detecting targets (at lower altitudes and clutter environment). The ATS, by sending only true target data to the ROCC computer, could reduce the amount of data the computer has to process. A significant reduction of data will reduce the demands on computer processing time and memory/storage space; both of which are nearly saturated.

PROJECT MANAGEMENT

1. In order to manage the demonstration, an Advanced Tracking System Project Management Team was established. The demonstration team leader is 11 TCW/DOX; other team members are listed in paragraph 3.

2. The charter of the project management team is to: set the demonstration objectives; develop evaluation criteria; conduct and observe demonstrations, record data on the results of the demonstration; evaluate the potential application of the ATS; and publish a project report.

3. The following agencies are participating or providing support for the ATS demonstration:

a. 11 TCW/DOXXQ -- Capt Pierce

b. 11 TCW/DOP -- SSgt Myher

c. 11 TCW/LGOR -- MSgt DeLuca

d. 11 TCW/LGKC -- MSgt Shuler

e. 11 TCW/LGKM -- TSgt Cushman

f. 744 ADS/DOO -- Lt McNeil

g. 21 st TFW/DOW -- Capt Hill

SYSTEM DESCRIPTION

1. The AN/GYQ - 51, Advanced Tracking System, manufactured by Litton Data Systems is a state of the art tracking system, providing sensor interoperability between centralized, decentralized, and autonomous air surveillance systems. The ATS is a front end processor located at the radar, intelligently filtering true targets from clutter and sending only actual track data to the command center for display. This capability allows larger volumes of actual track data to be transmitted over communications channels without resorting to desensitizing or blanking of the radar.

2. The ATS functions by detecting, establishing, and displaying tracks without operator intervention. The ATS accomplishes these functions through a four step process:

a. considers all radar returns via scan to scan processing;
b. identifies true targets;
c. establishes tracks using true targets; and
d. maintains tracking continuity using predictive logic.

DEMONSTRATION OBJECTIVES

Purpose:

There are four objectives of the demonstration. The overall purpose of each is to show how the Alaskan Theater's surveillance and command and control environment can be enhanced by the Advanced Tracking System.

Objectives:

1. Reduce demands on the FYQ-93 ROCC central computer; processing time and memory space. At present, central computer processing time and memory storage space is nearly saturated; while memory storage in the processor controller is overloaded to the point it "dumps" data.

2. Radar Enhancement: Regain loss of probability of detection, sacrificed at the expense of clutter reduction solutions to the radar. With the ATS's ability to extract true targets from clutter, the radar beam could be lowered thus increasing the probability of detection of low level targets.

3. Increase probability of detection by reducing human variability in the detection/tracking process. The ATS serving as a front end processor at the radar will automatically detect, establish, and pass target data to the Region Operations Control Center (ROCC). The presentation of only true targets in the ROCC will eliminate operator decisions concerning the validity of targets. This will increase the probability of establishing air tracks. Also because only true targets are presented, maintaining track continuity will improve for both computer tracking algorithms and when operators override computer tracking.

4. Role of the ATS in Alaska: By analyzing the data collected during the demonstration, we will draw inferences concerning the utility of the ATS in Alaskan Theater. Areas of interest: advantages of incorporating the ATS at each AN/FPS-117 in Alaska from a sensor interoperability standpoint; added measure of safety in large scale exercises.

Procedures

1. The following procedures serve as a guide to ensure successful completion of the four objectives for the demonstration.

2. Three radar sites (Cape Romanzof, Kotzebue, and Tatalina) will be used to collect data to satisfy objectives one and two (reduce demands on the FYQ-93 ROCC central computer, and radar enhancement). These sites were chosen because they possess the latest clutter reducing software (i.e. ECP 175 and the Multiscan Detection Processing (MDP)). At different times each day, data will be collected from each site for a period of 105 minutes. Each fifteen minutes, within the data collection window, the radar will be placed into a different configuration (e.g. ECP 175 enabled and MDP disabled). Data will be collected via data reduction, later collated on the Site Data Sheets (figure 1) and analyzed.

3. Data will be collected using low level flights (if available) in the ACMI range. This data will be used to assess the ATS's ability to enhance the probability of detection (Pd) of the
FPS -117 radar.

4. A tracking test will be used to meet the third demonstration objective (increase probability of detection by reducing human variability in the detection/tracking process). A operator will be selected at random and given an area of responsibility (AOR) to initiate and maintain track continuity on all tracks in the AOR. The operator will operate with and without the benefits of the ATS and all track histories will be recorded via data reduction. A comparison will be made of the data collected from the data reduction products to determine whether or not an operator will realize an increased probability of detection by reducing human variability in the detection/tracking process. Detailed instructions will be provided to each surveillance operator by the project coordinator--thus insuring a degree of procedural standardization.

5. In order to meet objective four, the potential role of the ATS in Alaska, inferences will have to be drawn based upon the data collected in objectives one through three.

THE ATS DEMONSTRATION LOG

The purpose of the ATS Demonstration Log is to ensure accurate and timely recording of data during the demonstration.

The ATS demonstration log shall contain the following information:

a. Site

b. Start time

c. End time

d. Radar configuration:

1. ECP 175 (Anomalous Propagation) activated (beam raised or lowered).
2. MDP "ON" or "OFF".
3. Data count without the ATS (search only).
4. Data count without the ATS (SIF only).
5. Total data count without the ATS (Search and SIF).
6. Data count with the ATS (search only).
7. Data count with the ATS (SIF only).
8. Total data count with the ATS (Search and SIF).
9. Number of tracks without the ATS.
10. Number of tracks with the ATS.

e. ACMI data for comparison.

f. Record of ROCC track histories for comparison, data reduction.

Data Products

Data products required to ensure accurate analysis.

1. ATS demonstration log. This log will be maintained at the Air Surveillance Technician position.

2. Data reduction, hard copy print out of flights within the ACMI. Flights will be recorded on tapes located at the ACMI. During playback, at the ACMI, hard copies of flight data will be made.

3. Data reduction from the FYQ-93 (ROCC) computer will be accomplished by 11 TCW/DOP covering the times of the demonstration.

ATS Demonstration

System Trouble Log

The System Trouble Log documents any difficulties experienced during the demonstration.

Date:______________________

Operator

Synopsis of Event:
(If needed, attach additional sheets)

Corrective Action:
(If needed, attach additional sheets)

ATS Demonstration

Personnel Familiarization Forms

The Personnel Familiarization Forms document equipment familiarization received by the Litton Data System representatives.

Litton Data System Representative:

Military Personnel Trained

Name	Date	Time

DATA AUTOMATION SUPPORT REQUEST

The Data Automation Support Request form enclosed is a form developed and used by the 744 ADS to request data reduction.

RESOURCES

ITEM	FUNCTION	SOURCE
Advanced Tracking System (ATS)	Tracker	Litton Data Systems
Tactical Display Console (TDC)	Display for ATS output	Litton Data Systems
Work space	ROCC	USAF
ROCC computer ports	Data for ATS	USAF

ADVANCED TRACKING SYSTEM DEMONSTRATION TIME LINE

1 OCT 91

Time: TBD ATS and TDC equipment arrives to the Region Operations Control Center (ROCC).

2-4 OCT 91

0900- ? Installation and check out of ATS equipment.

7-9 OCT 91

Litton Data Systems representatives will conduct demonstrations of the ATS and providing familiarization to USAF personnel.

10 OCT 91

0800-? From this time forward, until the end of the demonstration, data will be collected from various radar sites at random times. This process will be accomplished solely by USAF personnel who have received familiarization on 7-9 Oct 91.

17 OCT 91

1700 Demonstration end: Data will be collected, compiled, analyzed, with results presented in an after action report.

OPERATIONS SECURITY (U)

1. (U) General: This section provides guidance for the planning and conduct of the ATS demonstration.

2. (U) The denial of protected information to an opposing force is a command responsibility. All commands and individuals associated with any aspect of planning, support, or execution of the ATS demonstration plan will safeguard operational information in accordance with the guide that follows.

ESSENTIAL ELEMENTS OF FRIENDLY INFORMATION (U)

SUBJECT REQUIRING PROTECTION

System	Item
AN/FYQ - 93	Data Counts
AN/FPS - 117	Multi scan Detection Processor
ON/OFF	Anomalous Propagation ON/OFF
	Radar Coverage
AN/GYQ-51 (ATS)	Track Detection Data

NOTE: Taken individually, EEFIs are **UNCLASSIFIED**. Taken as a whole, they are classified **SECRET**.

DISTRIBUTION

11 th Air Force	
CC	1
CS	1
CV	1
DO	3
XP	1
LG	1
ALASKAN NORAD REGION	
CD	1
11th TACTICAL CONTROL WING	
CC	1
DO	10
LG	3
SC	2
OTHER	
21 TFW/CC	1
21 TFW/DO	1
Litton Data Systems	2

HARRY J. KIELING, Col, USAF
Commander, 11th Tactical Control Wing

OFFICIAL

GEORGE A. PAHLS, Colonel, USAF
Deputy Commander for Operations

APPENDIX C

LRR ENHANCEMENTS STAFF STUDY

11th TACTICAL CONTROL WING (PACAF)
ELMENDORF AFB AK 99506-2270
28 FEBRUARY 1992

LRR ENHANCEMENTS
STAFF STUDY

PACIFIC AIR FORCES
11TH TACTICAL CONTROL WING
ELMENDORF AFB ALASKA 99506-2270

FROM: 11 OPG/DOXXQ
6900 9TH ST STE 301
ELMENDORF AFB AK 99506-2270

SUBJECT: LRR ENHANCEMENTS STAFF STUDY

TO:

PROBLEM

1. The 11 AF needs to acquire a system that will integrate existing systems i.e., 3DS, AICU, and ACMI, into a cohesive, efficient system, providing unseen benefits to the Alaska 2000+ Range Improvements Project.

Note: A large proportion of the attachments for this staff study come from the after action reports of Litton Data Systems and Sensis Corporation--copied with their permission.

FACTORS BEARING ON THE PROBLEM

2. Facts.

a. Radar data from the AN/TPS - 63 must be integrated into the ROCC. The benefits from the additional radar coverage provided by the TPS-63's needs to be disseminated and utilized to the fullest extent possible.

b. Currently, no capability exists to automatically insert flight data on military aircraft into 3DS. The NORAD Software Support Facility (NSSF) is working on CSCP # 4569 which would allow the automatic tell of military aircraft. Hence, creating the pathway needed to get data on military aircraft into 3DS. The solution the NSSF is trying to achieve is a major software change: no solution is on the horizon.

c. Track data on aircraft not equipped with ACMI pods, but still players in large force exercises (LFEs), are not entered into the ACMI.

d. Radar data on aircraft not equipped with ACMI pods are detected by LRRs surrounding the range; however, this information is only sent to the ROCC. The idea here is to provide data on exercise participants, not capable of being tracked by ACMI, to the ACMI via the LRR-ROCC/AICU-ACMI interface (see atch. 1). The results: a more complete, accurate air picture, providing an added measure of flight safety both to the military and civil sectors.

e. The communication interface between the LRR and the ROCC needs to be made more efficient. At present massive amounts of radar data, most of it useless clutter is being bulk encrypted and sent over the communications circuits to the ROCC (see atch.

2). Sending only true target information, filtered from the clutter, will reduce the burden on the interface, thereby making this interface more efficient.

f. Too much useless data is being sent to the ROCC computer for processing. Sending only data which contains true target information will inherently make the ROCC computer more efficient. Some of the benefits are: free up available memory, decrease the amount of stuff the computer has to process, create greater processor flexibility, redistribute the processing workload between PPC-A and PPC-B.

g. A human variability in the target detection and tracking process exists. Increased reliability of the radar data, see mostly true targets vise mostly false targets, overall air surveillance function of the ROCC more reliable and efficient (atch 3).

h. Systems, i.e., AICU, ACMI, CTIS/3DS, need to be integrated more efficiently. Information available to one system can be made available to another system. For example: track data the AICU receives from an LRR can be made available to both 3DS and ACMI.

3. ASSUMPTIONS.

a. Industry has the capability to solve the integration requirements we have established during this study.

b. The AICU will be able to receive track messages from the RDMS and route these messages back and forth between the 3DS and ACMI.

4. CRITERIA.

a. The solution must be able to reduce the burden on the LRR-ROCC interface.

b. The data that's being output is in a format that can be used by the ROCC computer as well as the AICU.

c. The solution must be able to integrate and interface the AN/TPS-63 radar data in the correct format into the ROCC where it will be routed via the AICU to the 3DS and ACMI.

e. The system must have an open architecture design, being able to be incorporated into future systems (i.e., ROMS/RAMMS).

f. Versatile user friendly workstations, providing self diagnostics and real time radar status monitoring, as well as GCI control.

DISCUSSION.

5. The discussion will take a look at how the Alaska 2000+ Range Improvements Project can made more efficient and solve some problems that has been plaguing Alaska for years. A solution will be offered, tested against criteria, and shown how this solution will solve the problem.

a. The last several years have seen the proliferation of stand alone systems. A common thread runs through the purpose of acquiring these systems: feed the large screen display, essential for making timely and accurate command and control decisions. With the shift in emphasis in missions in Alaska, from war time preparedness, needed in the cold war, to providing a premier training center for the entire military, these stand alone systems must be flexible enough to meet our needs. The purpose of this study was to see if there is a way of integrating these stand alone systems into a cohesive network, not only for the benefit of the large screen display for the battle commanders, but for all.

b. The 11 ACW calls the solution a Radar Data Management System (RDMS) (atch 1). The RDMS is installed at the radar site, and its function is to manage the data coming out of the radar sites. A closer examination of the RDMS and how it stacks up to our criteria will show the value the RDMS will have in the Alaska 2000+ Range Improvements Project.

c. Reduce the burden on the LRR-ROCC interface is the first criteria the RDMS must be measured against. The burden on the LRR-ROCC interface is the quantity of data having to be transmitted over communications circuits. Most of the data transmitted is useless--meaning clutter. The RDMS at the radar will contain software that will intelligently discriminate between true targets and false targets or clutter. Demonstrations by Litton Data Systems and Sensis Corporation equally illustrated the dramatic affect of having a RDMS system at the radar site (see atch 4 & 5).

d. Sending quality data to the ROCC from the LRR is a great first step. The next step is to ensure the data that's being output is in a format that can be used by the ROCC computer as well as the AICU. The ROCC computer accepts only plot messages;whereas, the AICU accepts only track messages. Again, experience from contractor demonstrations has shown there are systems available that output data in more than one format. Such is the case with Litton's Advanced Tracking System, and Sensis Corporation's Multi-scan Correlator (MSC 2000) (atch 6 & 7). In atch 1, notice the RDMS will output plot messages to the Q-93 computer, while at the same time outputting track messages to the AICU.

e. Sending track messages to the AICU allows several things to happen. First, all aircraft detected by the radar, sent via track message to the AICU, can then be routed directly to 3DS. The interface will solve a long standing problem of how to get aircraft, especially military aircraft, automatically into 3DS for display. Second, track messages can also be routed by the AICU to the ACMI. The advantages this provides is all aircraft on the ACMI ranges not equipped with pods can still be displayed on the ACMI. For example, B-1's from a CONUS base fly a strike mission on the range during Cope Thunder. In the past, these aircraft would not even be seen on the ACMI;

although, they are players. The integration of the RDMS track message to the AICU to the ACMI will provide a more accurate and realistic picture. By virtue of being able to "see" these types of players, adds an extra measure of safety for both the military and civilian aviators. Finally, with the same track messages going to 3DS and the ACMI, an automatically updated picture can be seen by viewers of the ACMI and the 3DS. Recording and playback capability is the essential point here. Debriefings can occur simultaneously at geographically separated units. Litton and Sensis both output radar plot and track messages making integration possible today (atch 8).

f. Integrate the AN/TPS-63 radar into the ROCC is another important criteria. By having the TPS-63 radars on the Yukon ranges, will provide low level radar coverage never before seen. However, if the data from this radar doesn't go anywhere, the benefits will never fully be realized. Putting a RDMS in the TPS-63 will enable radar plot messages to be sent to the ROCC computer for display and radar track messages to be received by the AICU and routed to the ACMI and 3DS. Increased low level coverage, where none previously existed, increased flight safety, increased GCI awareness, large screen and ACMI display of low level non podded targets are all advantages of having an RDMS at the TPS-63. Both Litton Data Systems and Sensis Corporation indicate their systems can be used to integrate the TPS-63 into the ROCC (atch 9 & 10).

g. The RDMS must be a system with an open architecture design, being able to incorporate future systems (atch 11). The first "new" system is already becoming a reality with the installation this year of the Remote Operator Maintenance System (ROMS).

h. Versatile user friendly workstations are a necessity. The RDMS must have a workstation (located at the ROCC) with the versatility of being used to monitor the status of the radar on a real time basis. On the other hand, these workstations must have the flexibility to be used for either GCI control, or as a recording and playback station. The RDMS must have recording and playback features essential to training. Again, both Litton and Sensis have demonstrated workstations that could be used (atch 12 &13).

CONCLUSION.

6. An RDMS meeting the all the criteria providing benefits to the Alaska 2000+ Range Improvements Project does not exist, not yet, anyway. However, demonstrations conducted by Litton Data Systems, Sensis Corp., and GE Syracuse, have clearly shown that industry possesses the capability to meet our established criteria. A RDMS at the LRR would integrate radar data from both the AN/FPS-117 and AN/TPS-63 radars into the ROCC, 3DS, and ACMI while at the same time increasing the efficiency of the entire Alaska 2000+ Range network.

ACTION RECOMMENDED.

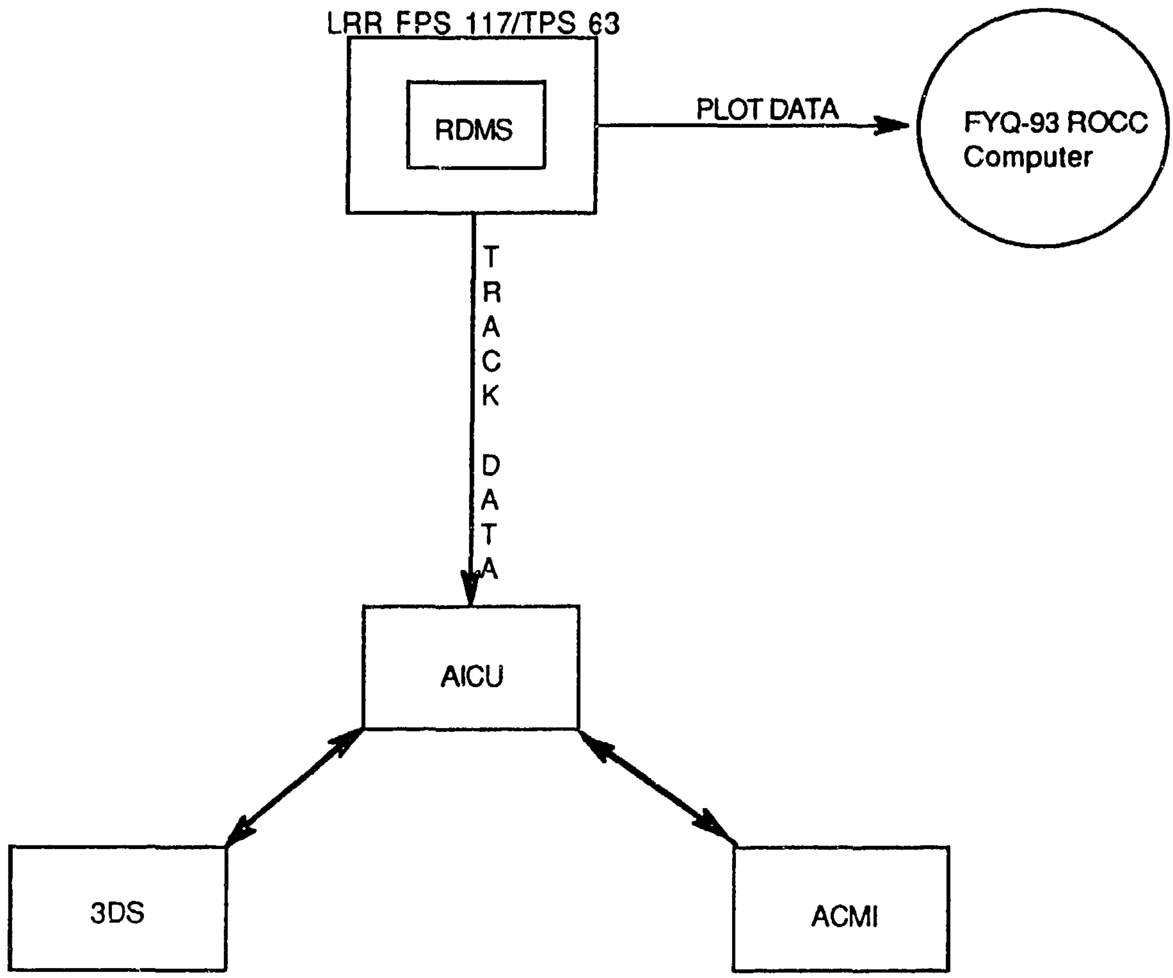
7. Procure a device, such as a RDMS, located at the LRR, which will provide the radar data management capabilities as described above.

GEORGE A. PAHLS, Colonel, USAF
Vice Commander

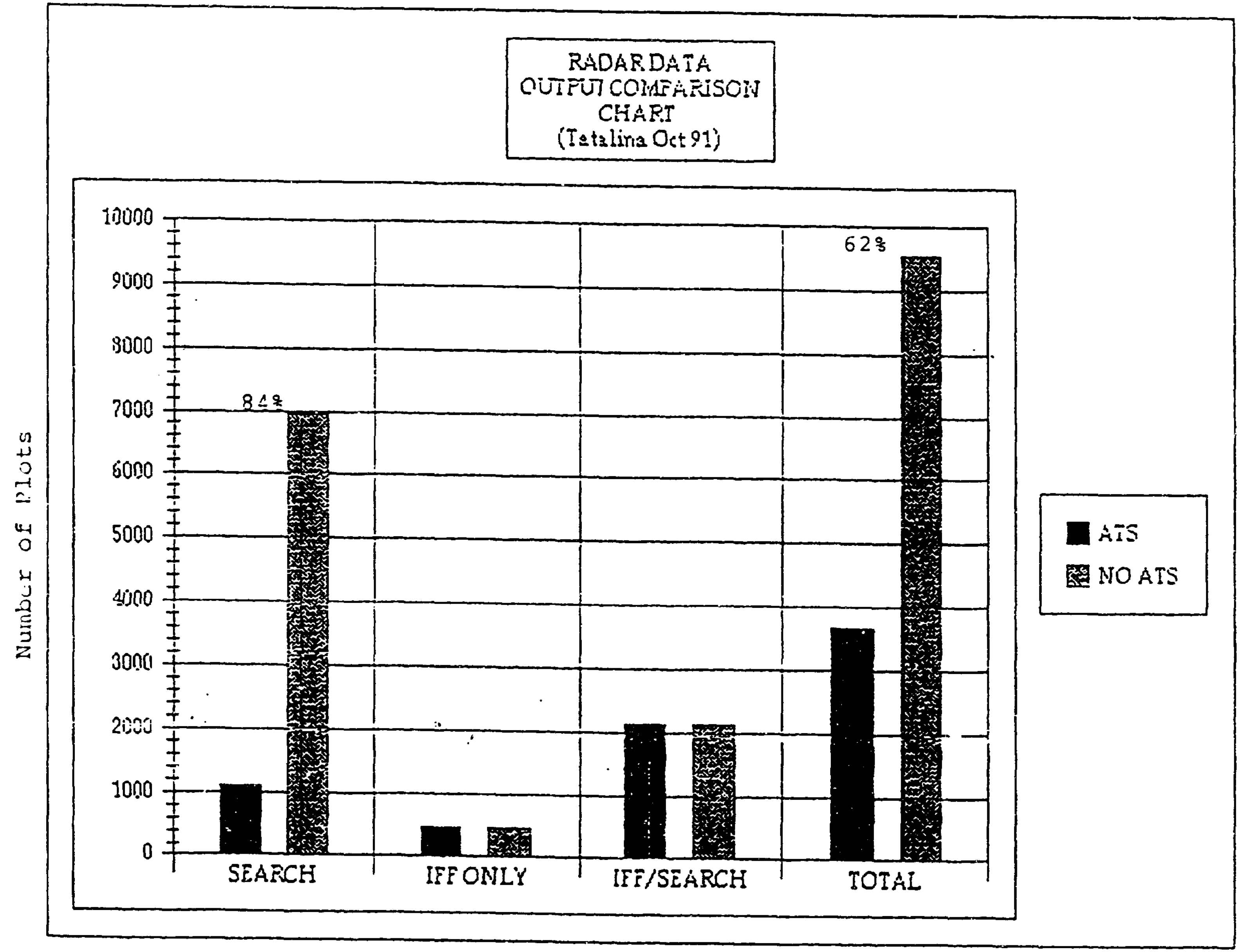
13 Atch

1. RDMS Integration Scheme
2. Radar Data Output Comparison Bar Graph
3. Radar Scope Comparison Data
4. Analytical Data: From Litton Data Systems Final Rpt
5. Analytical Data: Sensis Corp. From Final Rpt
6. Litton data, stating plot and track message output
7. Sensis data, stating correct message formats
8. Sensis data, integration capability with CTIS
9. Sensis data, integration capability with TPS-63
10. Litton Data Systems ltr, integration with TPS-63
11. Sensis Corp. stating open architecture design
12. Sensis Corp. statements on workstations rec/play
13. Litton statement on workstations, record/playback

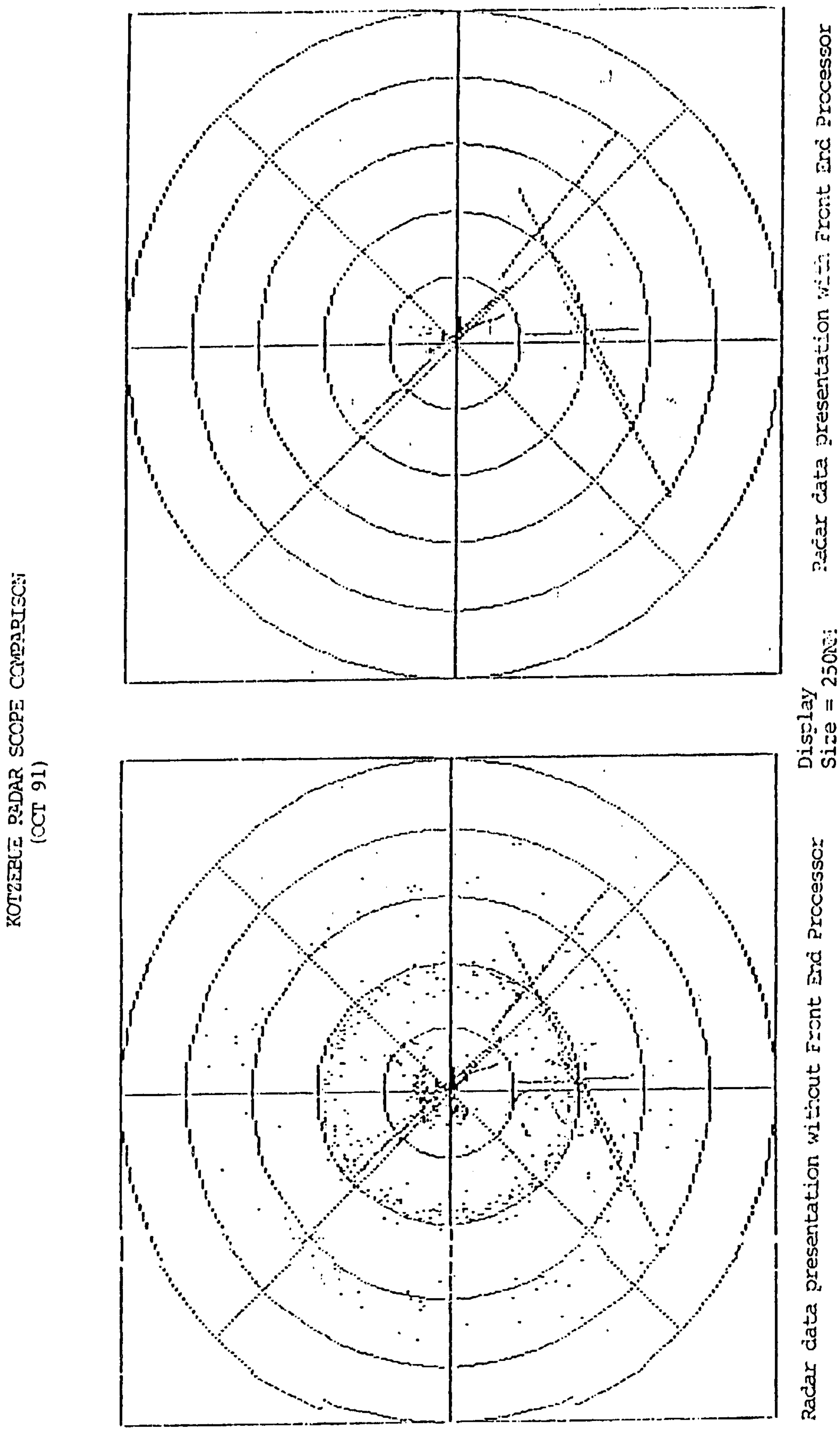
RADAR DATA MANAGEMENT SYSTEM (RDMS) INTEGRATION SCHEME



RDMS = RADAR DATA MANAGEMENT SYSTEM
AICU = ADVANCED INTERFACE CONTROL UNIT
ACMI = AIR COMBAT MANEUVERING INSTRUMENTATION
3DS = DIGITAL DECISION DISPLAY SYSTEM



This graph illustrates the significant difference in the amount of data sent from the radar to the ROCC for processing with and without a FEP. Search plots are reduced by 84% and the total amount of data (plots) are reduced 62%.



Atachment 3 Radar Scope Comparison Data

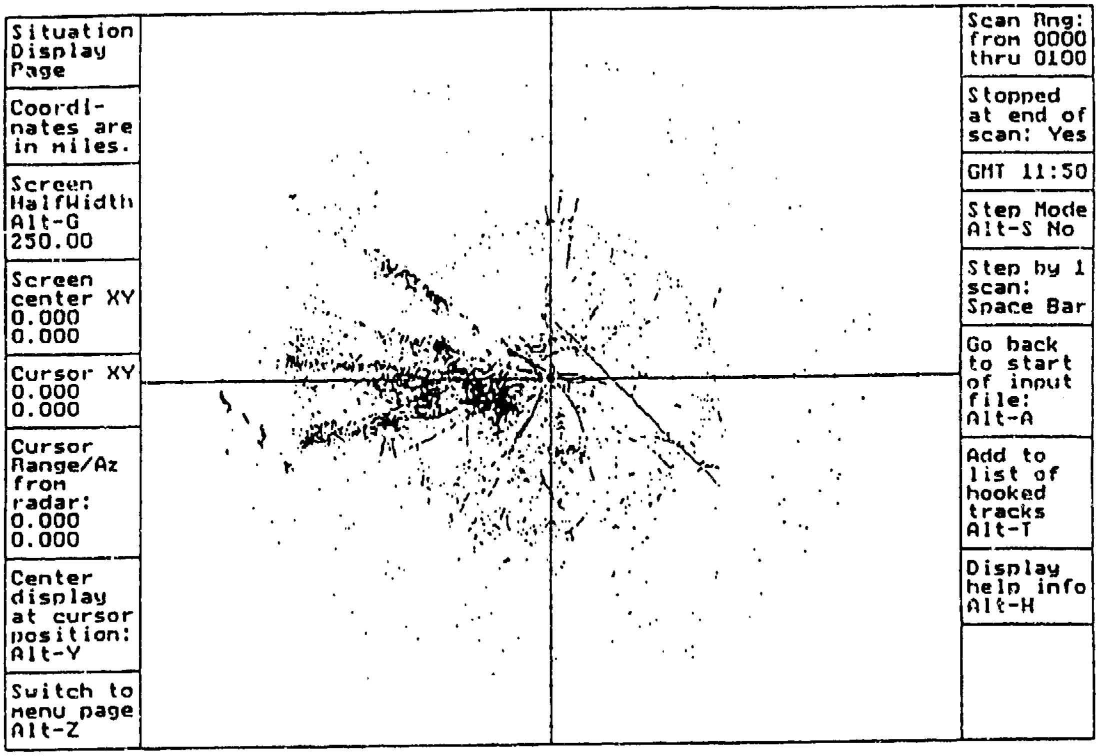


Figure 1-1a. Accumulation of all Target Reports from Kotzebue Radar, June 1991 - Large Concentration of Clutter Reports from Ice Floes and Other Sources Makes Manual Track Initiation Difficult.

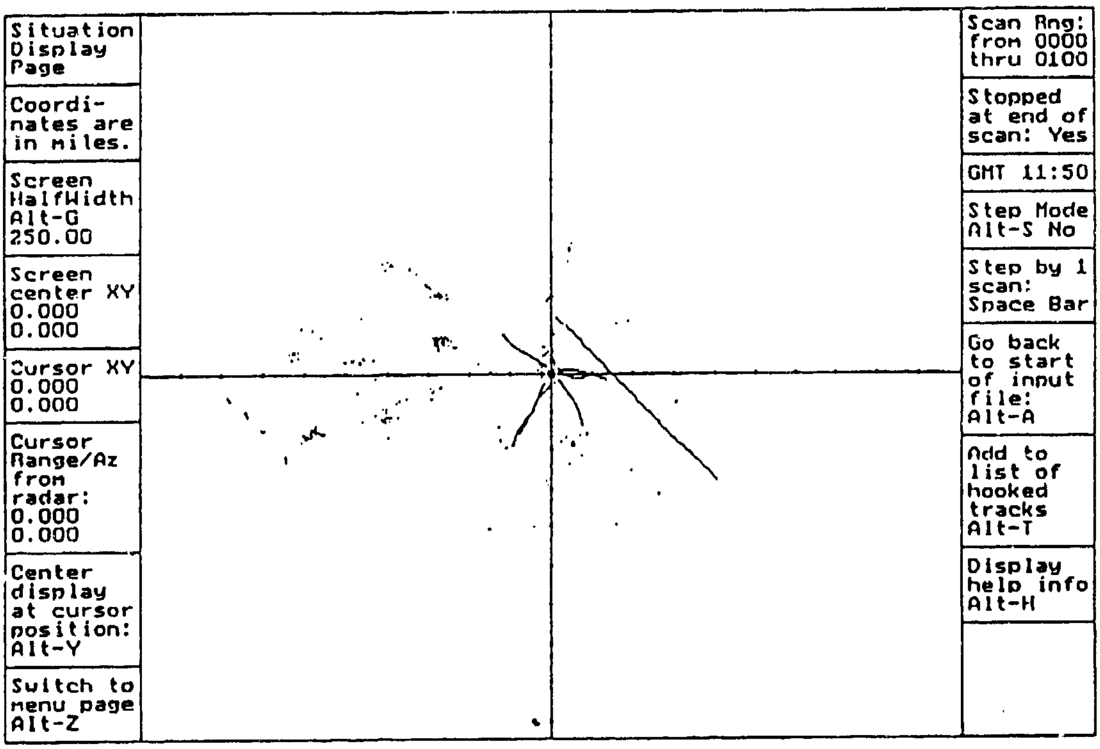


Figure 1-1b. Accumulation of all Target Reports from Kotzebue Radar as Output by ATS, June 1991 - Most Clutter Reports from Ice Floes and Other Sources Were Removed, Making Manual Track Initiation Less Difficult.

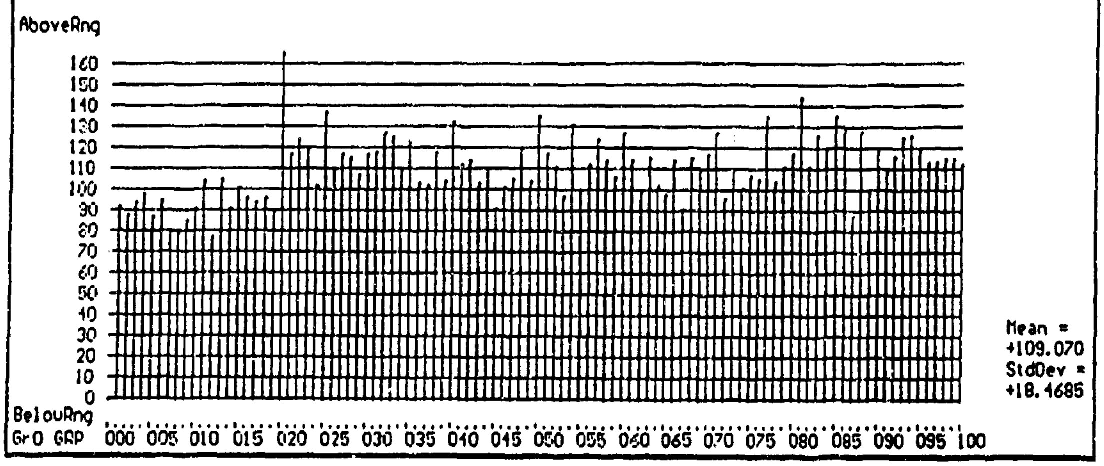


Figure 1-2a. Number of all Target Reports Output by Kotzebue Radar Each Radar Scan, June 1991 - The ASO Must Make Air Target Decision from Over 100 Target Reports

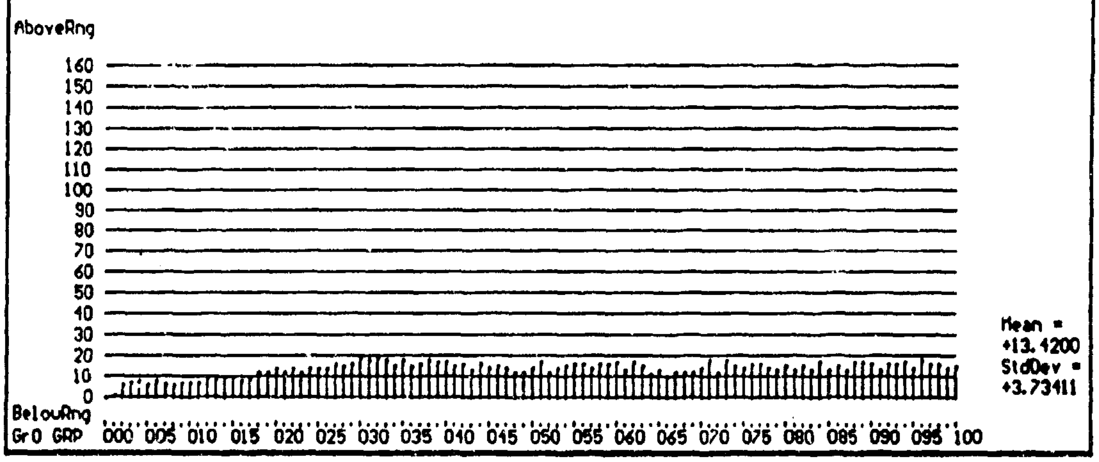


Figure 1-2b. Number of all Kotzebue Radar Target Reports Output Each Radar Scan by ATS, June 1991 - The Number of Target Reports for Which ASO Must Make Air Target Decision Has Been Reduced from 109 to 13

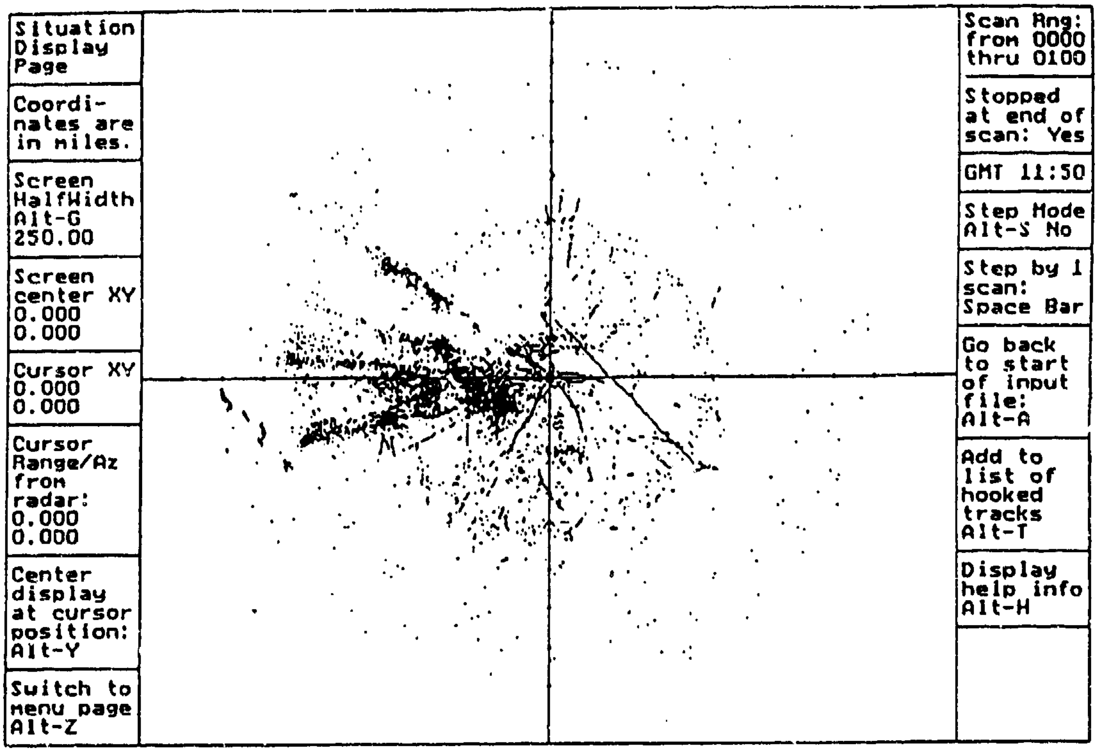


Figure 1-3a. Accumulation of all Radar Search Target Reports from Kotzebue Radar, June 1991 - Removal of IFF Target Reports Gives a Representation of Clutter

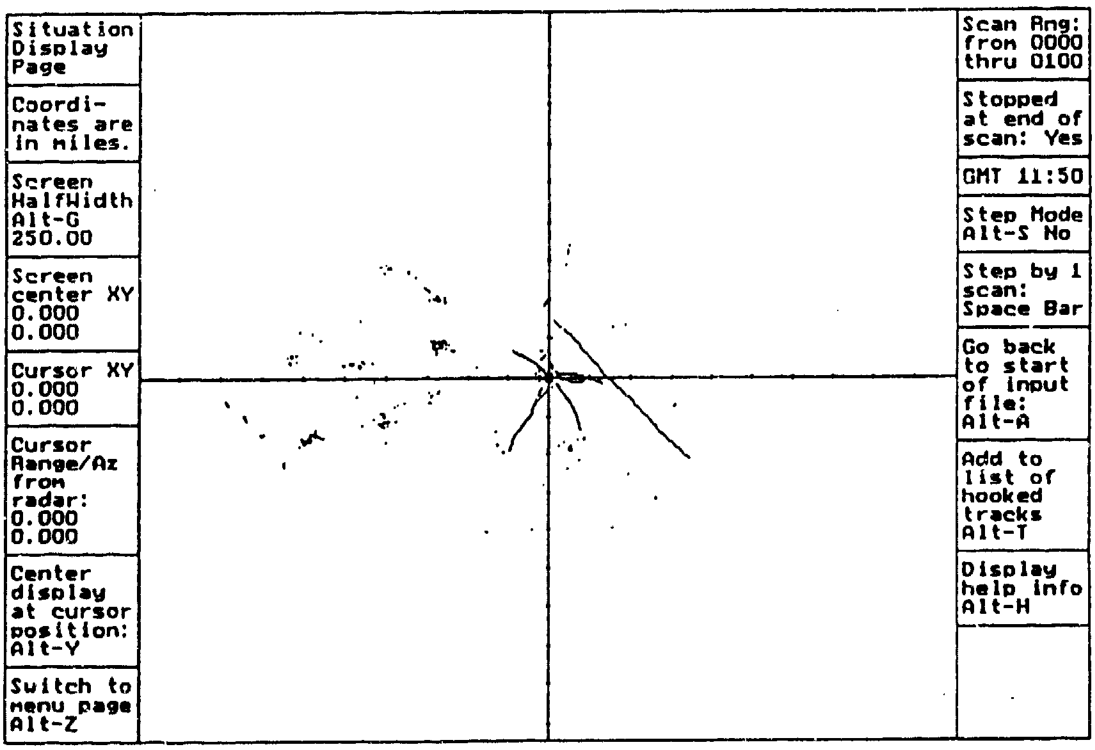


Figure 1-3b. Accumulation of all Radar Search Target Reports from Kotzebue Radar Output by ATS, June 1991 - There Were Few True Targets without IFF in the Surveillance Region

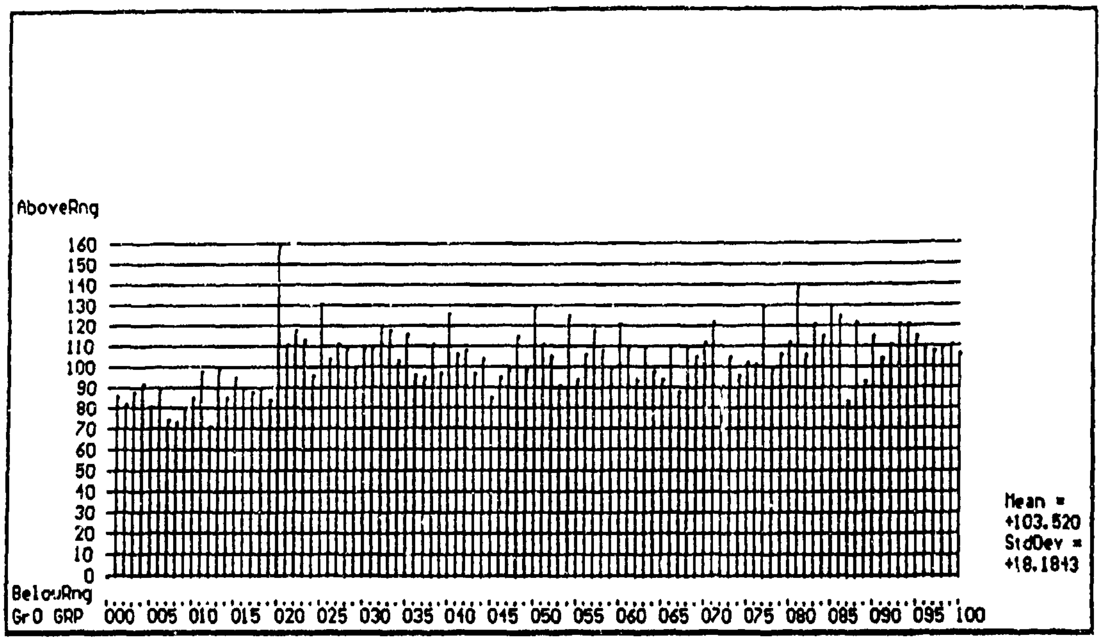


Figure 1-4a. Number of Kotzebue Radar Search Reports Output Each Radar Scan, June 1991 - Removal of IFF Targets Reduces the Number of Targets from 103 to 8

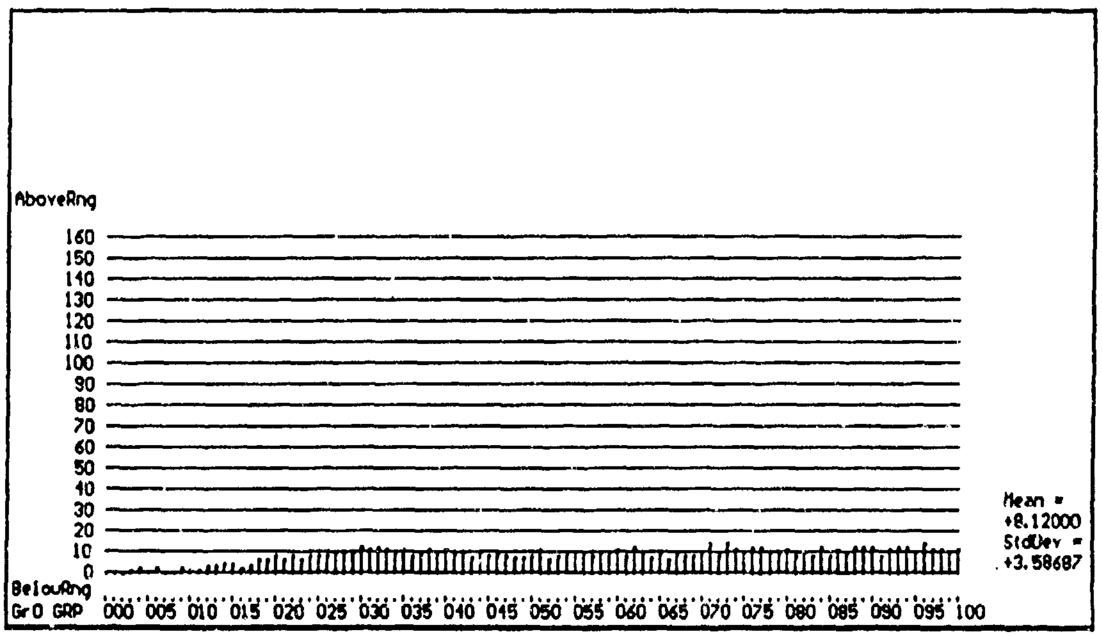


Figure 1-4b. Number of Kotzebue Radar Search Reports Output Each Radar Scan by ATS, June 1991 - Three of These Reports Are Due to Air Targets, Others Are Due to Clutter

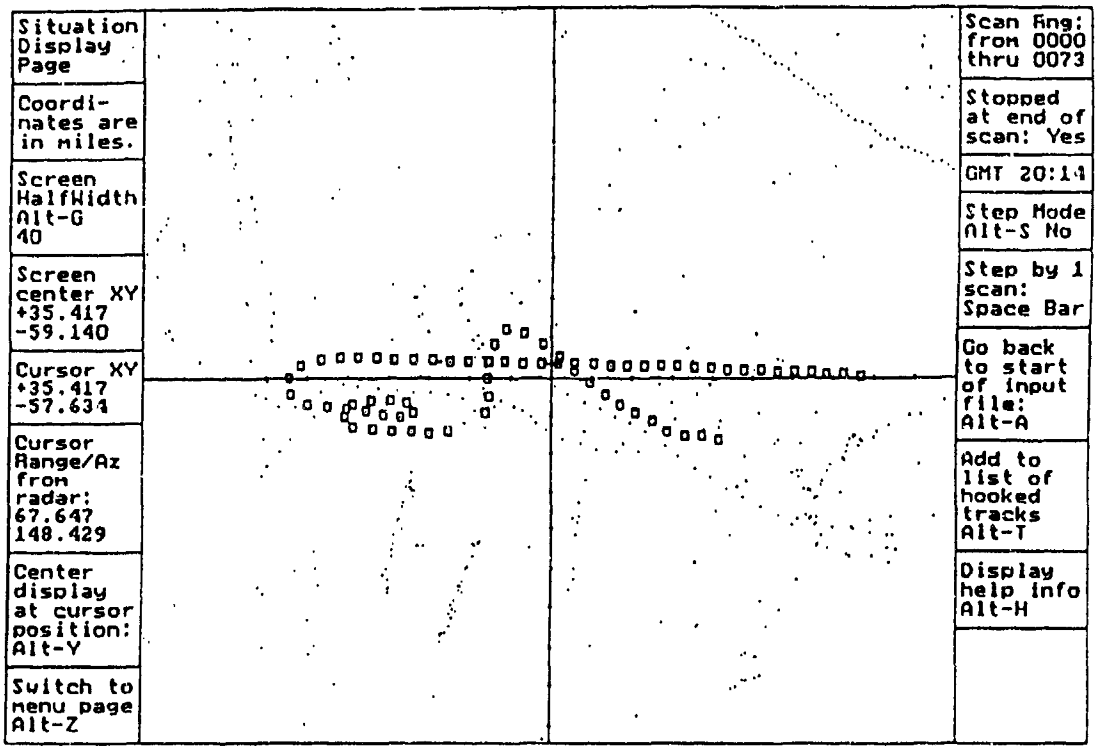


Figure 1-7a. ATS Track of F-15 Air Interceptor (Intruder), Tatalina Radar Site, October 1991 - The ATS Maintained Track Even During Rapid 180 Degree Heading Changes

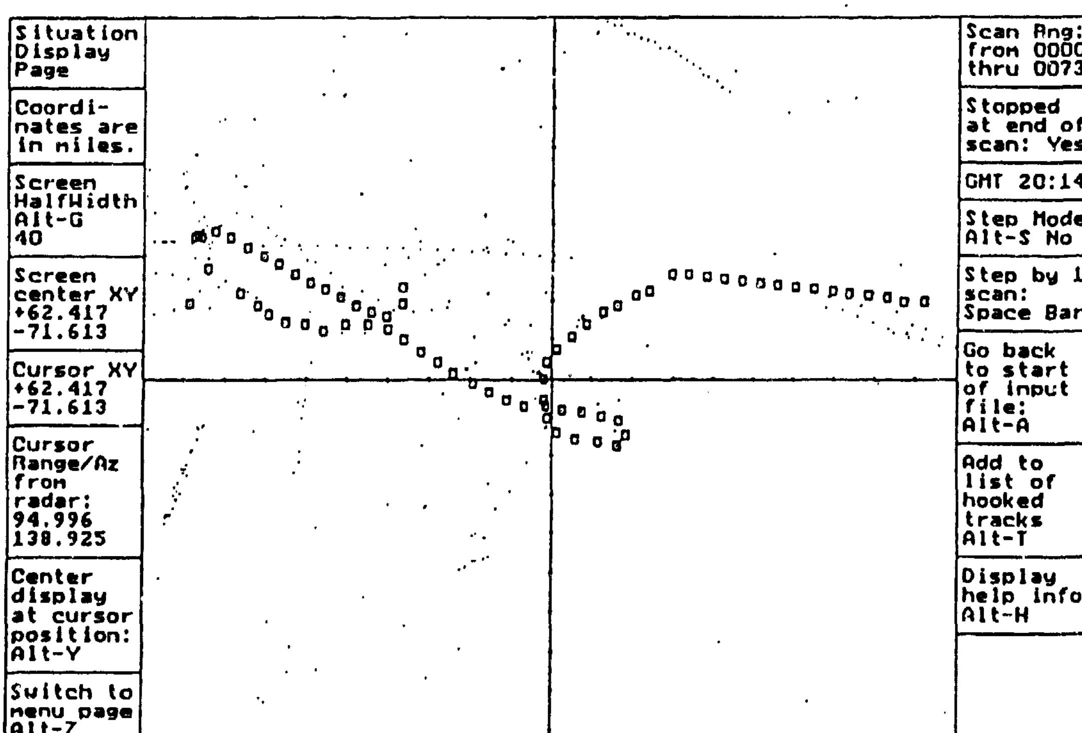


Figure 1-7b. ATS Track of F-15 Air Interceptor (Defender), Tatalina Radar Site, October 1991 - The ATS Maintained Track for all Except One Radar Scan Even During Rapid 180 Degree Heading Changes

3. DEMONSTRATION DATA COLLECTION AND ANALYSIS

3.1 False Alarm Rejection Performance

Captain Pierce supervised the connection of the MSC and the collection of data from four AN/FPS-117 sites: Tatalina, Tin City, Kotzebue, and Cape Romanzoff. Radar output data was collected from each site for a period of approximately 20 minutes for the purpose of determining the false alarm rejection capability of the MSC. The collected data was analyzed off-line using Data Analysis and Display Software (DADS) previously developed by Sensis. A summary of the false alarm rejection results is presented in Tables 3.1. through 3.3

Table 3.1 False Alarm Rejection of the MSC on FPS-117 Radars

Primary Radar Reports			
Radar Site	MSC Input	MSC Output	False Alarm Rejection Ratio
Kotzebue	934	34	27.5 to 1
Tin City	2643	88	30.0 to 1
Cape Romanzoff	474	45	10.5 to 1
Tatalina	2252	179	12.6 to 1

Table 3.2 False Alarm Rejection of the MSC on a 2D Radar

Primary Radar Reports			
Radar Site	MSC Input	MSC Output	False Alarm Rejection Ratio
Kenai	6,595	236	28 to 1

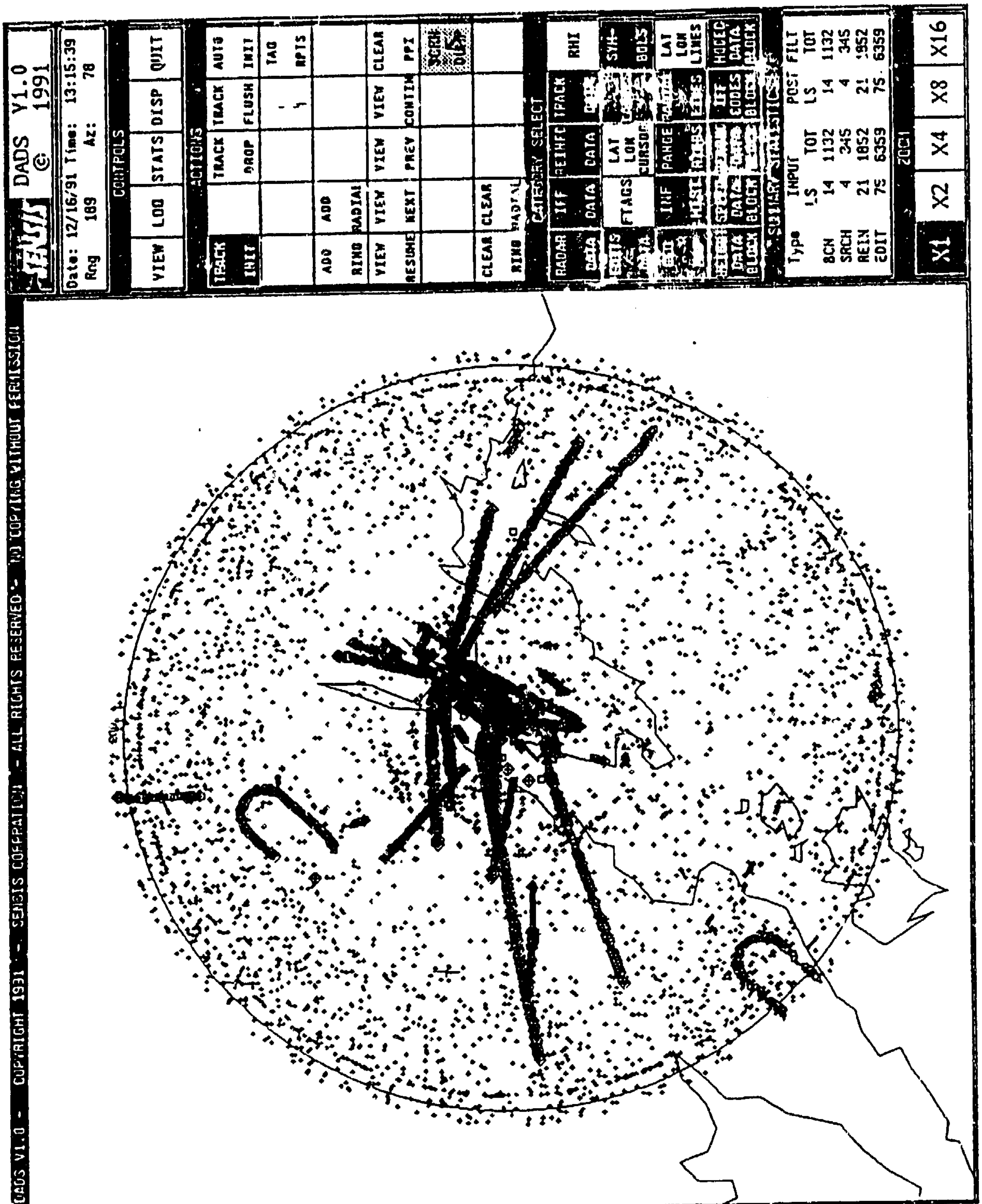
Table 3.3 Comparison of the MDP AND MSC

Primary Radar Reports			
Radar Site	MDP Output	MSC Output	False Alarm Rejection Ratio
Tin City	933	25	37.3 to 1

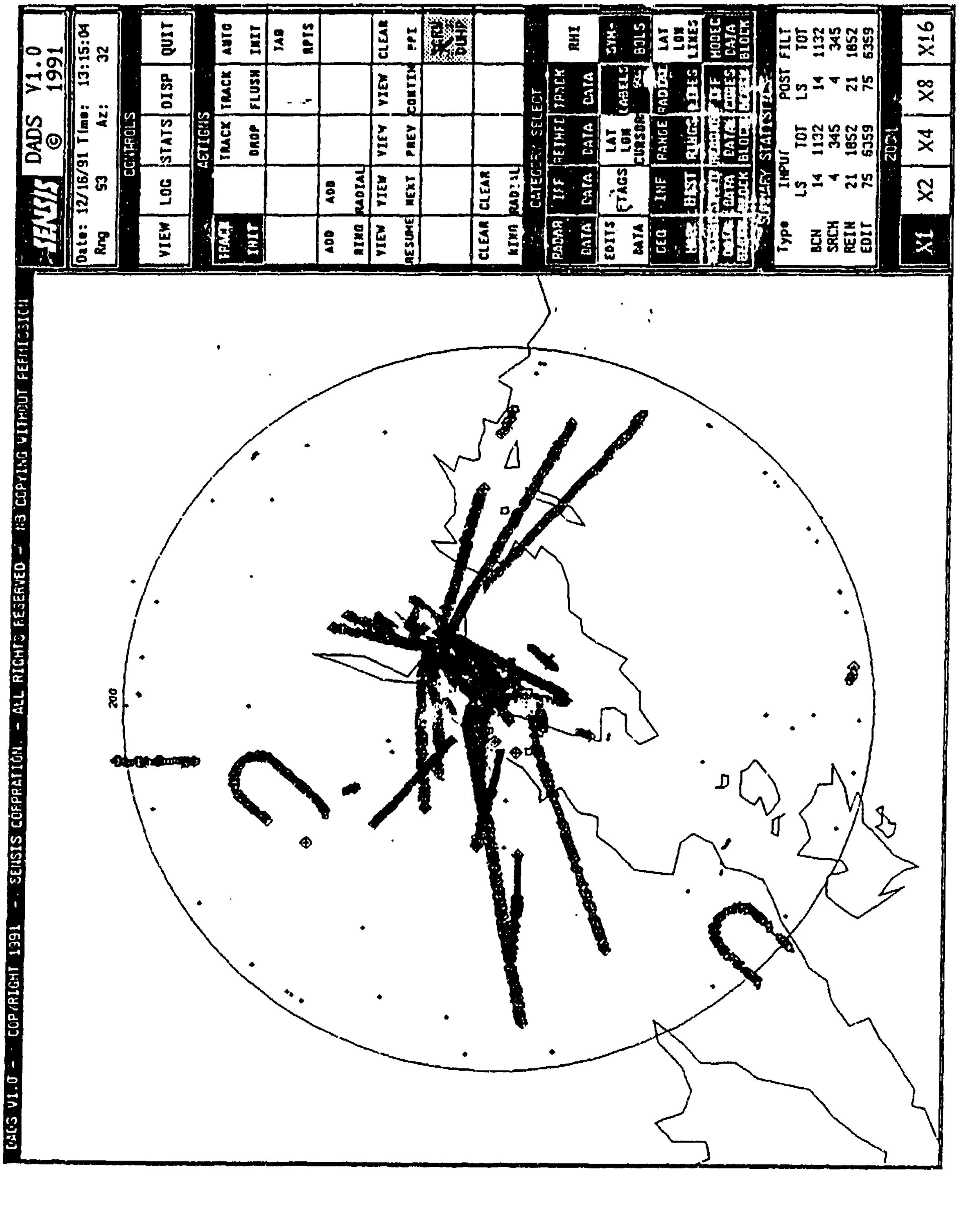
The DADS program was also configured to display all scans of the recorded data (approximately 100) for each site. Once the data file playback had been completed, the screen dump feature of the DADS program was used. This enabled the user to "take a snapshot" of the display and transfer the output to a laser printer where a hard copy is printed. The diamond-shaped symbols with a plus sign in the center

Cape Romanzoff Data with MDP Off and MSC Off.

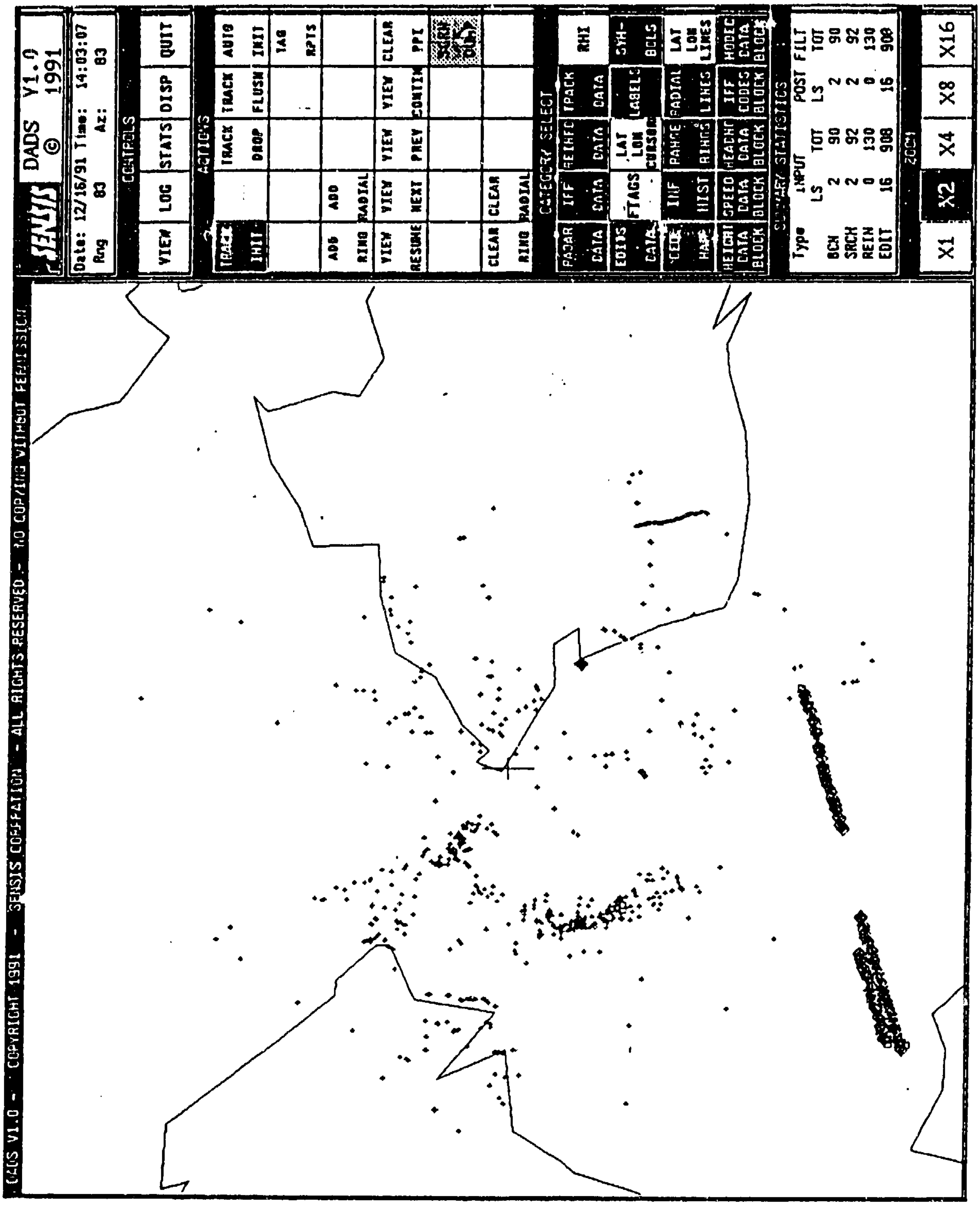
Cape Romanzoff Data with MDP Off and MSC On.



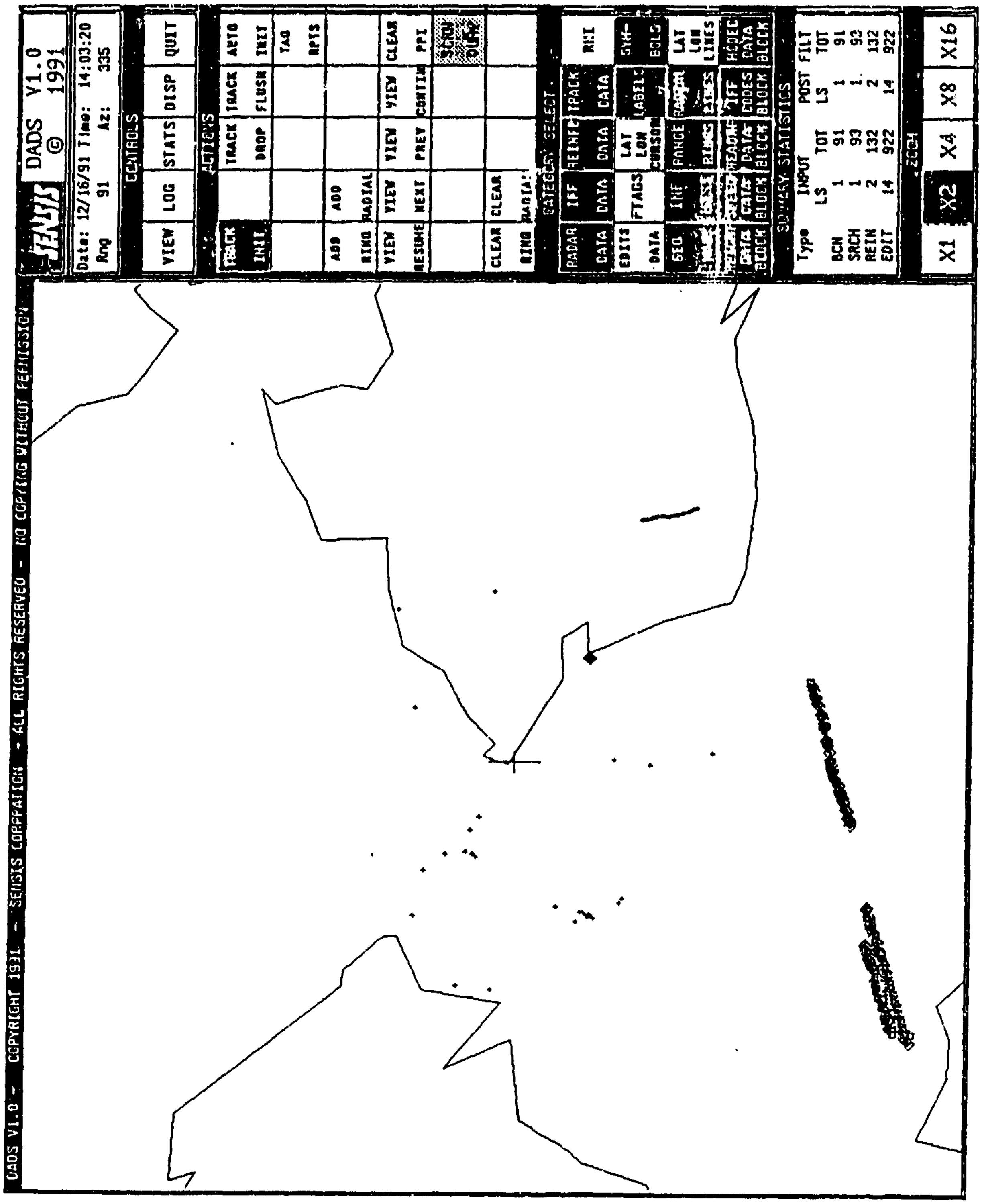
Kenai Data with MDP Off and MSC Off



Kenai Data with MDP Off and MSC On



Tin City Data with MDP On and MSC Off.



Tin City Data with MDP On and MSC On.

AN/GYQ-51 Advanced Tracking System (ATS)

A High Performance Extractor/Tracker for Improved Air Surveillance

INTRODUCTION

The AN/GYQ-51 Advanced Tracking System (ATS) is a post processor with radar beacon target extractor and tracker capabilities to significantly improve air surveillance effectiveness. The ATS has many advanced design features that distinguish it from conventional extractor equipments to provide improved small target detection in clutter. Its embedded adaptive tracker automatically creates and maintains a target track file which facilitates interoperability with systems requiring filtered plot or track data inputs. These include fixed site Operations Centers (SOCCs/ROCCs) and mobile systems like the AN/TYQ-23 Modular Control Equipment (MCE). ATS has been rigorously evaluated and tested by the USAF and selected exclusively as the discriminator/tracker for the TAC AN/TPS-43E and AN/TPS-75 radars used with the USAF MCE, and with the USAF aerostat radar program. It is also presently employed in the U.S. Customs Service Southwest Tethered Aerostat (STAS) Program. Requirements have been established for 56 additional USAF units, 18 USCS units, 1 ROKAF unit, with emerging requirements for 28-30 more ATSs. As such, the AN/GYQ-51, Advanced Tracking System, has become the USAF and USCS standard post processor/advanced tracker.

Recent live ATS Demonstrations in Alaska (with the General Electric AN/FPS-117) and High Rock, Bahamas (with the Westinghouse TPS-63) prove its adaptability to interface with a wide variety of older and new-generation radar systems.

IMPROVED DETECTION AND FALSE ALARM PERFORMANCE

The ATS upgrades air surveillance system performance to improve overall mission effectiveness. The ATS improves radar detection performance by allowing radar detection processing to operate at maximum sensitivity and applying post detection integration in the tracker to extract true targets from the background plot noise. The radar and target extractor within the ATS operate to achieve optimum small target (low RCS) detection by accepting all the radar's plots, then allowing the tracker to perform track-before-detect processing by applying multi-scan integration. This process uses all available plot data to determine the presence of true targets from amid clutter in the surveillance volume.

Employing this two stage detection process allows the ATS to achieve optimum detection performance without sacrificing false alarm performance. Conventional extractors do not employ post detection integration and consequently compromise small target detection to preserve an acceptable false alarm rate. Most of that conventional false alarm reduction is accomplished through "fixes" to the radar (e.g. sector blanking, raising the elevation beam angle, raising the sensitivity level). These fixes do reduce clutter in the affected area, but at the price of not detecting all of the real aircraft. The ATS achieves its improved detection performance without these radar fixes, through adaptive target extraction, noisy area tracking, and automatic target discrimination.

In applications of the ATS with the FPS-117, the radar continues to perform all the target extraction functions. The ATS receives the radar's plot data via the message output channels. The FPS-117 does not produce the conventional radar video that would allow the ATS to perform the plot extraction process (as with the TPS-63). Instead the ATS extractor is by-passed and the plot data from the radar is processed by the tracker in the very same way it processes internally generated plot data. However, the FPS-117 plot extraction function should be optimized for maximum sensitivity and probability of detection (PD), with none of the frequent fixes which reduce false alarms, but also reduce the opportunity to detect real aircraft as well.

Noisy Area Tracking

The ATS advanced tracker uses adaptive noisy area tracking techniques and automatic target discrimination to determine the presence of true targets and reject false alarms. The objective is to preserve the optimum PD achieved in the extractor, and eliminate false alarms to an acceptably low level at the output of the ATS system. Plot data from the extractor function is automatically processed by the high capacity, high performance adaptive tracking function within the ATS. Noisy area track initiation is performed on <u>all</u> input data. The target behavior model defines the envelope of target dynamics that meet the true target criteria used by the multi-scan track initiation process. It is through this process that the true targets are discriminated from the background false plots.

The track initiation function is capable of rejecting large numbers of false plots in the process of testing all possible plot combinations for true target characteristics. Typically, many thousands of trial tracks are created and tested in performing this operation. Most are rejected as combinations of false plots that exhibited brief periods of true target behavior. With few exceptions, only true targets in the surveillance volume become established ATS tracks. Once those tracks are established for the true targets, the established tracks are used as the target true reference to automatically discriminate plots from the radar extractor (i.e., sort out the noise and clutter). The resulting output consists of the true targets and very few false reports.

Automatic Target Discrimination

Based on the measured false plot density within individual surveillance regions, the ATS determines the eligibility of plot for output to the Operations Center. In clear areas (receiver noise only), plots are output without discrimination, as the likelihood of plots being true targets in these clutter free regions is high. In those areas where the false plot density indicates a noisy region, plots must correlate with established tracks to be output by the ATS. Beacon plots and their reinforcing radar returns are always output without discrimination. This plot filter criteria is therefore an intelligent selection process based on measured noise levels and established target tracks. This differs significantly from the conventional, totally censored clutter areas where target detection goes to zero. This capability has been demonstrated as crucial in meeting PD and false alarm performance requirements in the latest generation radar applications. Detection and false alarm rate requirements are such that post detection processing is the only workable solution for eliminating the false plots created by highly sensitive radar systems (e.g. FPS-117s and Aerostats).

INTEROPERABILITY

The ATS has proven essential in providing a high PD and low false alarm plot input to Operations Centers for a variety of radars. The SOCCs/ROCCs for example, are not tolerant of false alarms, as is true of many similar centers. Their central processors can handle no more than 10 to 15 false alarm plots per scan per radar, in order to successfully process all of the system's radar data. Otherwise, communications links from the remote radars to the SOCC/ROCC become overloaded, and/or the Q-93 computer system's processing capacity becomes stressed and slowed, creating significant operational degradation, or prompting implementation of those radar fixes which "unplug" or "sector-out" entire sections of the regional surveillance volume. The ATS's capabilities to reduce clutter <u>at the radar site</u>, while increasing PD over true targets, has been field-proven to alleviate many of these current systemic SOCC/ROCC problems.

CONCLUSION

The ATS is a proven, high performance post-processor/advanced tracker that improves surveillance performance to meet small, low flying target PD requirements. By the use of automatic and adaptive extraction and tracking, the ATS enhances radar performance for small target detection and false plot control. The ATS is particularly effective in high clutter environments caused by weather, birds, sea state, topography and even ECM. The ATS also provides a local target track file at the radar to support automatic track data tell to Operations Centers, offering substantial improvement in maintaining continuity of operations with a distributed target data base.

The ATS is now accepted as a fielded necessity for detection and tracking in many early warning/air surveillance environments, achieving here-to-fore unobtainable automation of the surveillance function.

February 1992

- Captured "pictures" of the ASD and printed hard copies on a laser jet printer.
- Successfully decoded the "ROCC Status" message in real-time and displayed the results in man-readable textual format on the ASD.
- Successfully generated real-time measures of radar performance such as: message counts per scan; parity errors (per channel); bad or unrecognized messages; beacon reinforcement rate; primary reinforcement rate; and track quality.
- Successfully recorded radar data for two sites simultaneously and played the data back for post-mission analysis in either Plan Position Indicator (PPI) or Range-Height Indicator (RHI) format.
- Provided numerous ASD features including zoom, offset, reorigin, track blocks, track vectors, tabular displays, SIF locate, and continuously updated range and bearing calculations.
- Using Sensis developed "Data Analysis and Display Software" (DADS), successfully displayed and analyzed recorded radar data.
- Rejected false alarms far better than the MDP algorithm implemented within the DDP -- the MSC further reduced the false alarm rate out of the MDP on the AN/FPS-117 at Tin City by a factor of 39.6 to 1.

The important operational capabilities which Sensis can provide in a singularly cost-effective way include:

- Enhancing range-safety throughout the Yukon MOA by optimizing the performance of the AN/FPS-117s and the AN/TPS-63 via a two step process: one, increasing radar sensitivity at low elevations and through valleys by proper selection of detection thresholds, STC attenuation and elevation beam pointing angles; and two, employing MSCs to effectively control false alarms.
- Integrating ROCC track information into the CTIS network by developing a special interface board (a derivative of the UNIO™ board within the MSC) which taps into the data stream broadcast from the Display Controller to the HMD-22(J) console.
- <u>Providing radar plot and track data on an Ethernet LAN where it can be picked off and processed by new "open architecture" data processors and displays without interfering with current ROCC operation. The key to this realizing this capability is to put MSCs at the radar sites to reduce the amount of plot data (by eliminating false alarms) to the point that the track data also available from the MSCs can be added and transmitted to the ROCC over existing data links.</u>

By presenting data and supportive discussion, the following report sections substantiate the assertions made here relative to the level of demonstrated performance and the potential for improved operational capability. Estimates of the cost and schedule of several specific programs proposed to enhance the ROCC's operational capability are also included.

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By presenting data and supportive discussion, the following report sections substantiate the assertions made here relative to the level of demonstrated performance and the potential for improved operational capability. Estimates of the cost and schedule of several specific programs proposed to enhance the ROCC's operational capability are also included.

4.2 AN/TPS-63 Improvement

The key to improving the performance of the AN-TPS-63 is simply to reduce the number of false alarms it generates through the use of the MSC. Our conservative estimate is that the MSC will reduce the AN/TPS-63's false alarm rate by more than 10 to 1. This judgment reflects the performance which the MSC achieved on the ARSR-3 at Kenai (i.e., a 28 to 1 false alarm rejection ratio) and our experience with an aerostat-borne AN/TPS-63 in Yuma Arizona. The MSC cut the false alarm rate out of the Yuma radar by 15 to 1, and because the moving aerostat has line-of-sight to a great deal of vehicular traffic, the problem is far more difficult. An example of the performance witnessed on the Yuma AN/TPS-63 is provided in Figures 4.8 and 4.9. They indicate the multi-scan search-only outputs at the input and output of the MSC, respectively.

Two unique interfaces are available to handle AN/TPS-63 plot outputs. The USMC radar utilizes an NTDS parallel interface and other versions utilize a three channel serial output format. Sensis has experience with both interfaces. The MSC has the demonstrated capability to accept NTDS format messages, perform false alarm rejection processing and output the data over two serial, synchronous data channels in the ROCC standard message format. It also has the demonstrated capability to accept data from the aerostat borne radar over three serial channels, perform false alarm rejection processing and output the data (with no data loss) over two serial, synchronous data channels in the ROCC standard format.

Litton

Data Systems

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Van Nuys, California
91409 7601

818 902 4000

10 February 1992

Captain Mark Pierce
11th Tactical Control Wing/DOX
6900 9th Street, Suite #301
Elmendorf AFB, AK 99506

Dear Captain Pierce:

Enclosed find the requested Advanced Tracking System (ATS) specification information. It contains detailed ATS specification data on applicable government documents/Mil-Standards, system and functional characteristics, logistics and reliability, and basic Quality Assurance/Verification Test provisions.

The ATS is a military nomenclatured system, the AN/GYQ-51, which has been in successful field use by the Air Force, U.S. Customs Service and Air National Guard for several years. In addition, new ATS systems have recently been delivered to Raytheon Corporation for use in the Warner Robins AFB PAVE PAWS program, to the Korean Navy Tactical Data System (KNTDS) and to General Electric for the HYPAR program in Turkey. Fourteen more systems are in production at this time for a variety of other customers, including NORAD.

The continuing success and reliability of ATS stems from Litton's extensive history of providing state-of-the-art, automatic target detection and tracking equipments to interface with various search radars and IFF sets. Between 1979-85, Radar Beacon Digitizers (RBDs) were delivered for diverse military and civil applications in Iceland, Ft. Huachuca, several Navy FACFACs, Berlin's Tempelhof airport, and the USMC's Marine Air Traffic Control and Landing System (MATCALS). Litton's newest tracker, the ATS, began development in 1981, and led to the MCE Interface Group (MIG) which performs stand-alone target extraction and advanced tracking for the Air Force's MCE system. The latest ATS version, commonly referred to as "STAS" (for the Southwest Tethered Aerostat program), is the most highly refined automatic tracker available.

It is important to note that, for potential Alaskan applications, the ATS interfaces with a variety of radars other than the FPS-117. <u>That includes full interoperability with the TPS-63 or ARSR-3 series radars, not to mention tactical radars that may deploy to the theater.</u>

Please contact me with queries, or any requests for follow-on data.

Jack Griff
Program Manager
Air Operations

2. DEMONSTRATION CONFIGURATION

A block diagram of the MSC hardware configuration employed in the demonstration is shown in Figure 2.1. As shown therein, two MSCs were used simultaneously.

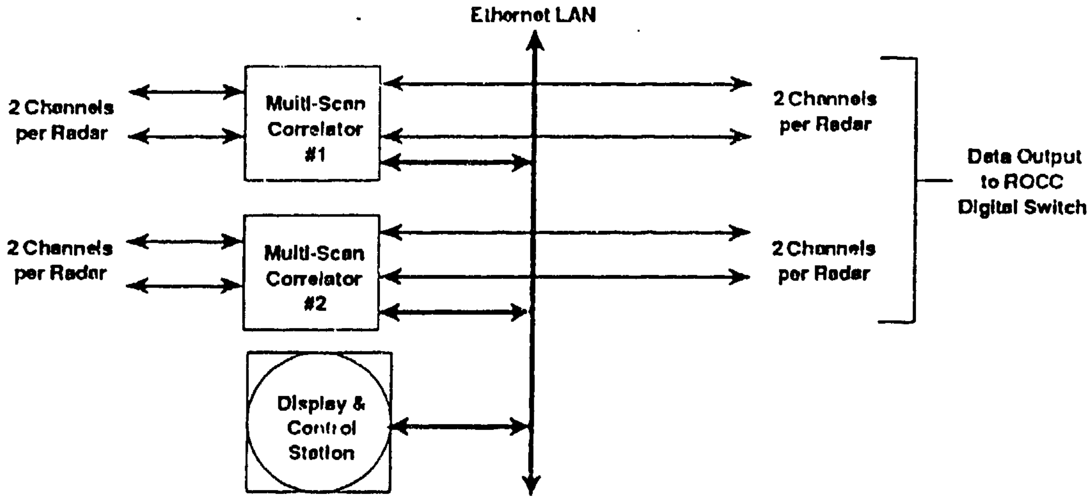

Figure 2.1 Demonstration Hardware Configuration

Both units were placed on top of the Digital Switch located in the ROCC computer room. The MSCs were connected to serial maintenance ports of the digital switch through standard DB25 cables. Data processed and filtered by the MSCs was transmitted onto an Ethernet Local Area Network (LAN) using TCP/IP protocol. The cable was laid under the floor to a SUN SPARCstation display and control terminal placed next to a ROCC Radar Display Unit (RDU).

Within 30 minutes after being unpacked, and with no hardware adjustments or modifications, the MSC equipment was properly set up and processing live radar data. The setup was accomplished without interrupting or, in any way, interfering with system operation. Jumper wires were used to connect the radar data and clock to the appropriate input and output pins on the MSC.

2.1 Multi-Scan Correlator

The MSC is a commercially available, in-production processor which reduces clutter induced false target reports without materially reducing target detectability. In fact, the significant reduction in false alarms realized by the MSC permits an increase in radar sensitivity, which can actually increase target detectability. The hardware consists of COTS sub-assemblies with the exception of one digital board which was specifically designed to efficiently handle a variety of serial synchronous and asynchronous message formats. It utilizes industry standards such as the VERTX real-time operating system, a VME bus interface, an Ethernet LAN, a RETMA

chassis and a TAF standard SUN workstation. Display and processing code is written in "C", a High Order Language (HOL).

The MSC is placed between the radar and communications modem, and performs the correlation processing required to eliminate reports from reflectors which don't move like true air targets. Returns which are eliminated this way include surface and volumetric clutter, long-range clutter induced by anomalous propagation (AP), and slow-moving targets such as vehicular traffic, birds and shipping vessels, Beacon and search-reinforced beacon returns are tracked internally but not removed from the data stream. The MSC is capable of handling up to 1600 reports per 12 second scan (twice the current data link capacity). A more detailed description of the hardware and software of the MSC is found in Appendix A.

Physically, the MSC is housed in a standard 19" RETMA rack mount chassis, 5 inches high and 24 inches deep. The chassis contains an internal power supply, two fans, an MVME147-1 68030 processor board and a serial interface board. The weight is less than 20 pounds and the power consumption is less than 150 Watts.

2.2 Ethernet LAN

All control communications and data transfer between the MSCs and the SUN workstation is accomplished via the Ethernet LAN. The modular nature of the system interface provides the capability to network several units together to obtain as many input ports as necessary. The bandwidth of the Ethernet LAN, 1 Megabit per second, is sufficient to accept radar inputs from over 100 sources at 4800 PPS. All of the incoming radar data is broadcast on the Ethernet LAN where it is available to be distributed to other non-proprietary computer systems which may be used in the future.

2.3 SUN SPARCstation

The SUN SPARCstation is a high performance processor with a high resolution display and built-in mass storage capability. The SUN utilizes the UNIX operating system and windowing to provide an efficient and convenient method for defining and generating displays and controls.

The Display and Control system implementation makes use of a keyboard and mouse or trackball for operator entry and selection of display information. Radar data and operator entries can be recorded and stored on the 300 Megabyte hard disk and transferred to magnetic tape for data archiving.

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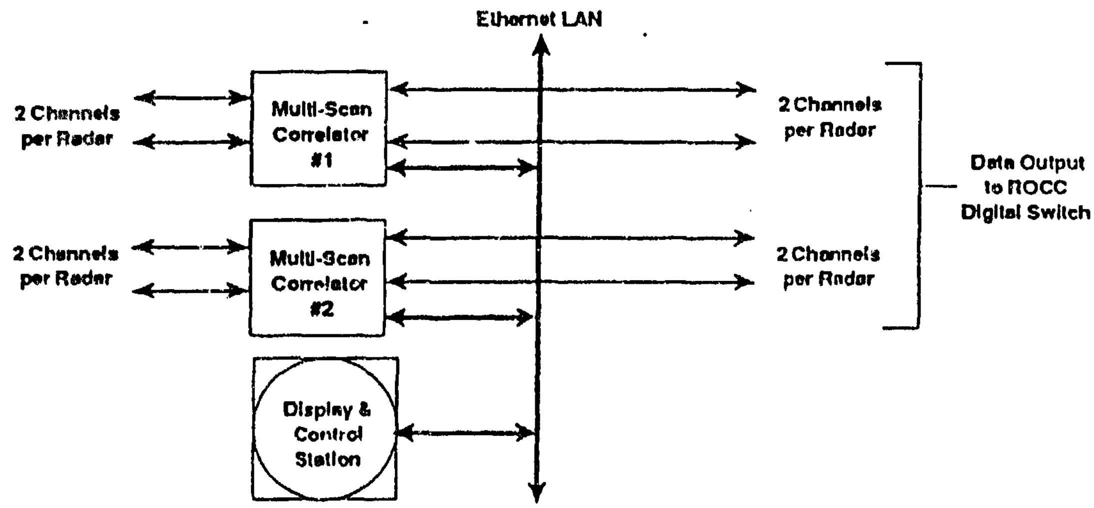

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9.4 Recording and Playback Capability

The Display and Control station will permit the user to record the received data on the SUN SPARC workstations internal hard disk memory unit and playback the data under operator control, in an operator designated file, assuming recording is enabled.

The SUN workstation is equipped with a 300 megabyte internal hard disk drive with a 150 Megabyte back-up magnetic tape drive for recording and archiving data. The Display Station can be utilized to record data from multiple radars simultaneously for later replay and analysis. Additional display stations can be added as requirements arise and one of the Display Stations could subsume the functions of the present RDU with a full color high resolution display.

The playback of previously recorded radar messages is also controlled via the Display and Control Station. The operator has the capability to specify the playback filename and to control the rate of playback. The rate of playback can be varied from a real-time rate to approximately 10 times the real-time rate. This feature is useful for viewing data files to search for specific characteristics or events. In addition, the file playback may be paused and restarted under operator control.

9.5 System Features Summary

In summary, the MSC offers the following features to the user:

- Modular Architecture: supports single-site remote installations or networking of multiple MSCs at the C3I Center
- Programmable "Universal" Interface Processor: provides transparent connection with existing data link protocols and the capability to perform channel data conversions through re-bauding and/or channel muxing
- Non-Volatile Storage of Site-Specific Parameters: for automatic self-activation upon power-up
- On-Line Control: permits user selection of certain parameters such as active and bypass regions, velocity gates and clutter maps
- Embedded Ethernet Local Area Network (LAN) Port: provides a common communication path for growth options including the CMC-2 subsystem and the networking of multiple MSCs
- Equipment Status: via built-in-test with front-panel indicators and status report messages to the CMC-2
- On-Line Performance Monitoring: performs real-time performance monitoring and health assessment with fault logging and automatic bypass in the event of a detected fault

Tracker Data Analysis System (TDAS)

The TDAS is a PC-based program for recording and analyzing ATS output data. Provisions are made for recording of (1) the raw plot extracted data, (2) the filtered plot reports generated by the ATS, and (3) the ATS track file as output to users who require Established tracks rather than filtered plots. TDAS is also used for analyzing recorded data and presenting the analyzed data for display. Provisions are made for hard copy printout of displayed data. In the Alaska ATS Demo, TDAS was used for generation of all the data presentations for this report.

A few of the TDAS capabilities pertinent to the ATS demonstration, and subsequent data analysis, are listed here:

1. Generate a geopositional display of radar target reports, filtered target reports or tracks. This display has most of the capabilities of the normal radar PPI display including radar centered display, display offset to cursor (ball tab) position, and range scale variation. Provisions for data retention for any number of radar scans is provided. Provisions are also made for stepping through recorded data one radar scan at a time (with data retention for as many radar scans as the operator chooses), clearing of the display, and continuation of the process. Hard copy printouts can be made at any step in the process.

2. Generation of scan sequence diagrams which present data values for each individual radar scan (up to 250 radar scans on a single display). Up to four scan-sequence diagrams can be generated at one time. Values of any track or plot parameter output by the ATS can be displayed. Examples are:
   a. The number of target reports output by the Target Detector each radar scan.
   b. The number of plot reports output by the ATS each radar scan.
   c. The number of tracks output by the ATS each radar scan.
   d. Speed, heading, height and track quality for any ATS output track.

3. Generation of histograms of data maintained in the ATS track file and output by the ATS plot filter. For example, the distribution of tracks with speeds in 25 mph speed intervals for speeds from zero to 500 mph.

APPENDIX D

EXPERIMENT PLAN AND REPORT FORMATS

GENERAL: Ideally, an experiment is reported on in two documents, an *experimental plan* that lays the foundation, and an *experimental report* that tells what actually took place and what the results were. For CC4003 we do not have time to produce elaborate experimental plans, so we move some of the information into the report. The following outline is suggested. Parenthetical notes identify information that could be in the plan, the report, or both.

1. **Introduction** (plan -- summarize in report)
   - A. Introduce the team
   - B. Purpose
     - (1) The *real world* problem the experiment will help solve
     - (2) The specific questions the experiment seeks to answer
     - (3) The approach
     - (4) Anticipated Results
   - C. Scope of Experiment
2. **Experimental Design** (plan --summarize in report)
   - A. Setup
     - (1) Physical
     - (2) Test subjects
     - (3) Special Equipment
     - (4) Schedule of Trials
   - B. Hypotheses
   - C. Assumptions
   - D. Statistical Design of Experiment

E. Measures

F. Instrumentation

G. Testing & Pilot Trials

3. Data Description (both: plan -- what will be collected, assumptions; report -- details)

A. Example of raw data

B. Data problems

C. Data coding scheme

D. Data table

E. Data Reduction

4. Analysis (both: plan -- how it will be performed; report -- details)

A. Analysis Plan	(plan -- summarize in report)
B. Methodology	(report)
C. Results of Analysis	(report)

D. Any additional assumptions that were required (report)

5. Conclusions (report)

A. Hypotheses Results -- Interpretations

B. Other Interpretations

C. Real world meaning of results

D. Experiment Summary

6. Recommendations (report)

A. Changes to the experiment

B. Continuation of the Experiment

APPENDIX E

EVALUATION OF STUDIES PARADIGM

Evaluating Studies
CC4003--January 1994

Simple		short, graphic, minimum
OBJECTIVE	clear & relevant	easy to understand, unambiguous, appropriate
ASSUMPTIONS	reasonable	logical, realistic, sensible, minimum
HYPOTHESES	germane	testing them accomplishes objective
EXPERIMENTAL DESIGN	comprehensive but executable	pertinent, observable, practical
MEASURES	quantifiable and discriminatory	numerical, accurate, significant, important
DATA	replicable	precise, well-defined, reliable
ANALYSIS	correct and unbiased	careful, scientific, statistical, reality
CONCLUSIONS	supportable	appropriate, valid, logical
Consistent		compatibility, direct linkage, pertinent

DEFINITIONS OF CHARACTERISTICS-EVALUATION PARADIGM

The objective is clear and relevant if it is easy to understand, unambiguous and appropriate to the goal of the study.

The study is simple if it is short and illustrative, has a minimum number of assumptions, alternatives, hypotheses and measures plus easily understood analysis and conclusions.

The assumptions are reasonable if they can be supported logically, realistically and sensibly. They should be the minimum necessary to limit the scope of the problem to viable choices.

The experimental design is comprehensive but executable if it tests all the pertinent hypotheses with measurable data by a practical analysis plan.

A hypothesis is germane if its test efficiently accomplishes the objective of the study.

Measures are quantifiable if they provide numerical values that accurately reflect the alternatives. The are discriminating if significant differences in their values reflect important differences in the alternatives.

Data is replicable if it is precisely defined and accurately measured and processed. A test of replicability is if repeated trials would produce the same data.

An analysis is correct if it carefully tests data with statistically sound methods. It is unbiased if the assumptions and methods applied reflect reality.

The conclusions are supportable if they are valid results of an analysis that follows logically from the study.

The study is consistent if there is compatibility in scope and detail at each step. In addition, direct linkage between the steps must maintain continuity with the objective.

APPENDIX F

REVISED EXPERIMENTAL PLAN

I. REVISED INTRODUCTION

A. PROJECT MANAGEMENT

The 11 ACW is going to conduct an experiment to assess the capabilities of the Litton Data Systems Advanced Tracking System (ATS).

1. In order to manage the demonstration, an Advanced Tracking System Project Management Team was established. The demonstration team leader is 11th ACW/DOX; other team members are listed in paragraph three.

2. The following agencies are participating or providing support for the ATS demonstration:

a. 11 ACW/DOXXQ -- Capt Pierce

b. 11 ACW/DOP -- SSgt Myher

c. 11 ACW/LGOR -- MSgt DeLuca

d. 11 ACW/LGKC -- MSgt Shuler

e. 11 ACW/LGKM -- TSgt Cushman

f. 744 ADS/DOO -- Lt McNeil

g. 21 st TFW/DOW -- Capt Hill

B. PURPOSE

The purpose of this experiment will be to determine whether or not Litton Data Systems Advanced Tracking System (ATS) is capable of more efficiently managing the flow of radar data coming into the Region Operations Control Center (ROCC). Managing the radar data more efficiently will enable the operators to realize the full operational capabilities of the new radars without overloading the ROCC Central Computer. As a result, the demonstration is designed to provide insight into the radar data management problems being experienced by the Alaska NORAD Region (ANR) and the ability of the ATS to

solve them. Specifically, the ANR would like to determine the validity of the claims of the ATS's capabilities. For example: Can the ATS accurately discriminate true targets from clutter? From an air defense point of view, can the ATS provide target discrimination without target elimination?

The demonstration will select three sites, all equipped with ECPs. All of the ECPs will be turned off for the demonstration in order to reestablish the radars to a fully sensitized state. The ATS must prove that it is capable of handling the data workload from a fully sensitized radar.

The ATS will not be installed at the selected radars because of the logistics and prohibitive costs. Instead, the ATS equipment will be installed in the ROCC.

The ATS will be connected at the ROCC Communications Segment, the point where the data arrives in the ROCC via satellite from the selected radars. The data arriving at this point has not yet been processed by the ROCC central computer. Therefore, connecting the ATS at the ROCC Communications Segment simulates the ATS processing the data at the radar site.

The next step will be to compare the amount of data a fully sensitized radar forwards with the amount of data a fully sensitized radar equipped with an ATS forwards. The ROCC provides the capability to simultaneously measure ATS and non-ATS data from the same site (see Figure 4)[Ref. 10]. The reduction in data, and the quality of the data must be analyzed simultaneously. The ATS may live up to its clutter reduction claims, but the data has to be analyzed to ensure that the ATS is not eliminating or erroneously manipulating valid air targets necessary for air defense and air training missions. In order to verify the target data, a specific number of aircraft, flying different profiles, will be used. The experiment will be designed to control the number of aircraft. However, the actual flight profiles along with the number of aircraft used during the test will only be known

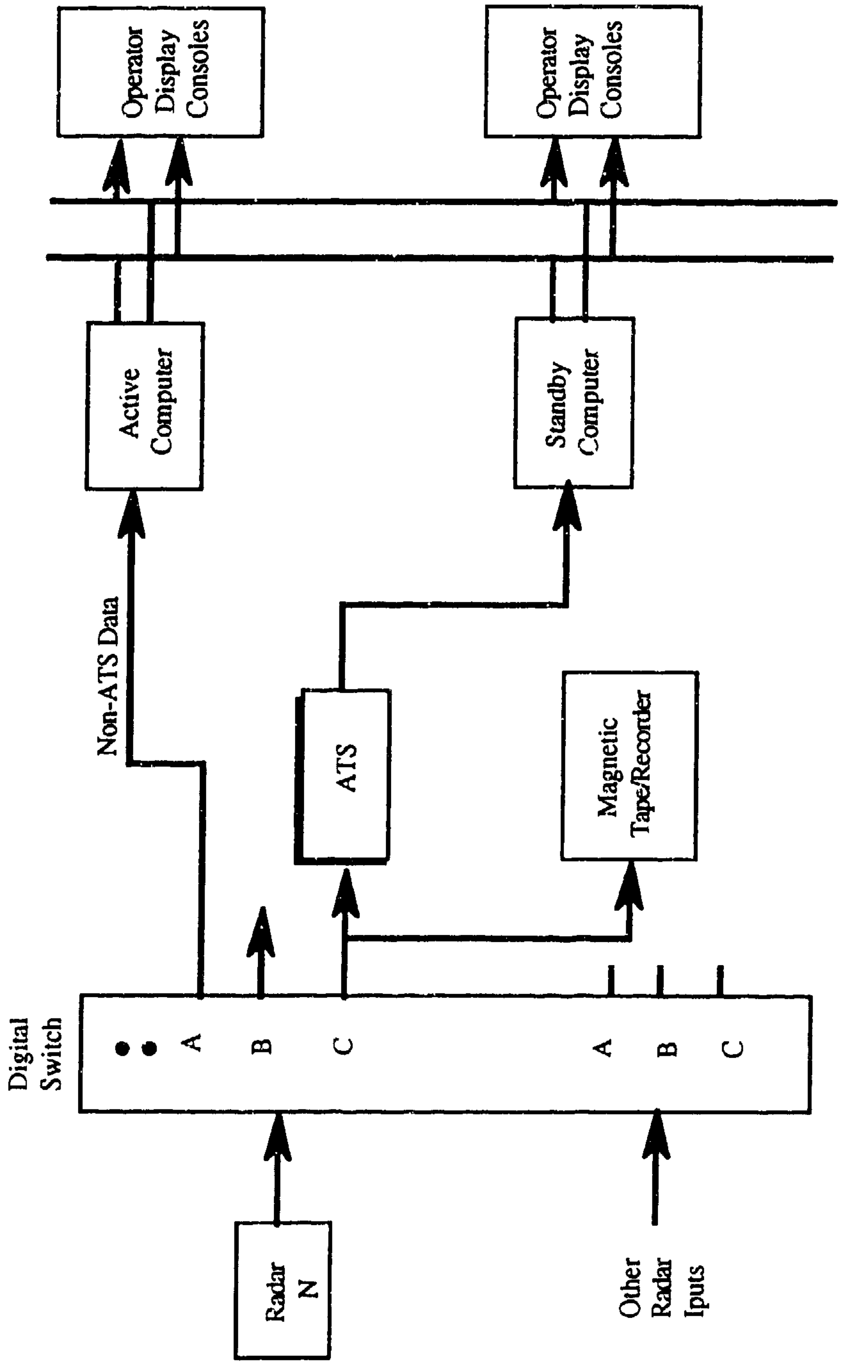

Figure 4 ROCC-ATS Interface

by a third party, disassociated from the experiment. Only after the experiment is completed and the analysis turned in will the aircraft portion of the experiment be revealed. The purpose of this single blind design is to eliminate any bias from the experimenters.

The anticipated results: Measurable differences between the quantity of data received from a radar in a fully sensitized state, when equipped with an ATS and when not, are expected. However, whether or not the ATS eliminates valid air targets remains to be seen.

C. THE SCOPE OF THE DEMONSTRATION:

This demonstration will provide the information the 11th AF Commander needs to decide whether or not the ATS (or other associated Radar Data Management System) provides viable solutions to the radar data management problems experienced by the ANR. There are several potential benefits if the ATS demonstration proves successful. First, ECPs can be eliminated from the radars, restoring them to their full operational capability, and providing greater low level detection of aircraft and missiles. In the area of training, the improved detection capability will increase the radar coverage in the low level training areas.

Benefits should also be seen in the ROCC central computer. Installing the ATS at the radar head will decentralize the computer processing. The ATS will discriminate between clutter and target data, dump the clutter data, and pass only the target data to the central computer for further processing. The main benefits to the central computer are reductions in the amount of processing required and the potential for a computer overload that arbitrarily dumps data.

The reduced computer workload will enable the installation of additional radars. This is important because PACAF wants to expand the air training ranges in Alaska. The eruption of Mount Pinatubo and subsequent loss of a major air

training exercise in the Philippines called Cope Thunder required more training, and thus an expansion of the air training ranges, in Alaska. As a result, additional radars are needed to provide coverage in these new training areas. However, the additional data from these sites could easily create an overload condition in the computer. Dumping data during a major exercise would seriously jeopardize the safety of the entire mission.

The life of the central computer will be prolonged because the amount of data the central computer has to process will be eased. Thus, the costly acquisition of a new generation ROCC computer can be delayed.

II. REVISED EXPERIMENTAL DESIGN

A. SETUP:

1. Physical

The physical setup is the crux of the entire experiment. The demonstration would not be possible if not for the flexibility of the ROCC system. Figure 4 depicts the actual physical interface between the ROCC and the ATS equipment. The following is a discussion of the ROCC-ATS interface.

The digital switch provides the interconnection between the communication channels from the radar sites and the central computer. The radar data at the digital switch has not been processed by the ROCC computer. Each radar sends its data to the digital switch at the ROCC via three 2.4 kbps communications channels. These channels feed directly into three ports associated with each radar at the digital switch. Two ports, designated A and B, are normally interconnected with the primary and standby central computers. The third port, designated C, is available for recording data on a noninterference basis. This is the location of the ROCC-ATS interface. At the same time, the cable from port B of the Digital Switch to the central computer will be disconnected at the computer, and the output from the ATS will be connected to the standby computer at its input channel (Figure 4).

2. Factors:

There are three experimental factors: radar sites at three levels; Litton ATS at two levels; and analysis equipment at two levels. Three radar sites have been chosen: Kotzebue, Cape Romanzof, and Tatalina (Figure 2). The ATS radar processing hardware/software is either on or off. Finally, the equipment being used to analyze the data is either third party, Air Force approved, test and

evaluation equipment or the Litton Data Systems analysis program associated with the ATS.

3. **Special Equipment:**

a. The ATS consists of all of the interface hardware as well as the software to conduct the data collection and analysis. All will be provided by Litton Data Systems.

b. A neutral third party will be involved to provide balance and legitimacy to the experiment. This third party (i.e. 84th Radar Evaluation Squadron) must conduct the experiment in parallel with Litton. They must interface at the same location, with the same site, and at the same time. They will collect the data, analyze it, and compare their results with Litton's experimental results.

c. Aircraft will be dedicated to fly certain profiles within the coverage limits of the selected radar.

4. **Schedule of Trials:**

The schedule of trials will not be formally addressed in this sample plan. The driving factor for the schedule of trials will be the availability of the aircraft needed to fly the flight profiles. Making up a schedule of trials does not provide sufficient lessons learned.

B. HYPOTHESES:

1a. There is no difference between the amount of data forwarded by the fully sensitized radar and the radar equipped with the ATS.

1b. The alternative: There is a difference between the amount of data forwarded by the fully sensitized radar and the radar equipped with the ATS.

2a. There is no difference between the number of targets reported by the ROCC computer combined with the fully sensitized radar and the radar equipped with an ATS.

2b. There is a difference between the number of targets reported by the ROCC computer combined with the fully sensitized radar and the radar equipped with an ATS.

3a. There is no difference between the third party analysis results and the Litton Data Systems analysis results.

3b. There is a difference between the third party analysis results and the Litton Data Systems analysis results.

The first two hypotheses deal with the issues of quantity and quality of the data the ATS produces. Does the ATS make a difference in the amount of data being sent back to the ROCC central computer? And, does the ATS discriminate targets from clutter without eliminating valid air targets?

The third hypothesis is designed to validate the Litton demonstration by determining whether or not the data is consistent with that from an established test and evaluation system. The 11th ACW staff must be sure that the ATS works as claimed and that the analysis tools that are part of the equipment package portray the data in an accurate manner.

C. ASSUMPTIONS:

1. Litton's interface hardware is compatible with the ROCC equipment
2. The software will provide the type of analysis needed to answer the research questions.
3. The weather patterns and clutter density at the three sites are representative of the (AOR) overall.

4. Both Litton and the third party Air Force evaluation equipment is capable of counting and keeping track of the number of targets received from the radar.

Note: This assumption is based on the claims of Litton that its software has the capability to compile this type of information [Ref. 3]. Additionally, since the ROCC computer, a 1970s version computer, has the capability to count the number of tracks in the system, and is certified, it is assumed that the evaluation equipment exists within the Air Force, or else the ROCC computer could not have been certified in the first place.

D. STATISTICAL DESIGN OF EXPERIMENT

The experiment is a 3 X 2 X 2 factorial single blind experiment. This means that one factor has three levels and the other two factors each have two levels. The first factor has three levels because of the selection of three different radar sites. The radar sites associated with these levels are: Kotzebue, Cape Romanzof, and Tatalina. This factor corresponds to hypotheses one and two stated above. The processing equipment is the second factor. The two levels are whether or not the radar is utilizing the ATS. This factor also corresponds to hypotheses one and two. The third factor is analysis equipment. The two levels for this factor are the third party operationally approved equipment and the Litton analysis equipment. This factor corresponds to hypothesis number three. The purpose of designing a single blind experiment is to eliminate experimenter bias and to serve as a means to evaluate whether or not the ATS is eliminating valid air targets.

E. MEASURES

The experiment is designed to evaluate the data forwarded by the radar. The data will be collected and reduced into two categories. The first category deals with the quantity of data and the second deals with the quality of data (target elimination). The categories of data are listed below.

Category one: Quantity. The total amount of data processed and sent by the radar to the ROCC, measured in bits per second.

Category two: Quality. The total number of targets being sent by the radar to the ROCC, measured by the total number of targets being sent by the ROCC computer to the operator.

F. INSTRUMENTATION

The instrumentation is the equipment used by Litton and the third party Air Force evaluation team to collect and analyze the data.

G. TESTING & PILOT TRIALS

Testing will be done to ensure the ATS and third party equipment can be connected to the ROCC digital switch. Additional testing will be done to ensure the commander that the experiment will not interfere with the daily operations of the ROCC.

After the interfaces are made, pilot trials will be run to ensure that the data being collected is the correct data to test the hypotheses. The researchers will use the pilot testing to practice the experimental procedures. For planning purposes, time should be allotted in the master schedule for the pilot testing.

III. REVISED DATA DESCRIPTION

Table 1 presents the data coding scheme. The table depicts the three factors (Radar Sites, Analysis Equipment, Processing Equipment) along with their associated levels. The number in parenthesis is the code assigned to the particular level. The coding scheme will become apparent when the table listing the different combinations of trials is presented below.

TABLE 1 DATA CODING SCHEME

Radar Sites	Analysis Equipment	Processing Equipment
Kotzebue (1)	Third Party (1)	Non ATS (1)
Cape Romanzoff (2)	Litton (2)	ATS (2)
Tatalina (3)		

The data is divided into two categories.

Data: Total amount of data received from the radar (X in bits per second)

Total number of tracks (Y)

The data is divided into two categories to aid in the analysis, but it will all be collected at once for each trial. The computer software of the evaluation equipment will reduce the data into the X and Y categories designated above.

Table 2 depicts the combinations of levels of the factors. There are twelve combinations of factor levels, found by multiplying one factor with three levels and two factors each with two levels. Each of the trials will be replicated thirty times in order to assume the data approximates a normal distribution.

TABLE 2 TRIALS

Trial #	Radar Sites	Analysis Equip.	Processing Equip.	Data (X)	Data (Y)
1	1	1	1		
2	1	1	2		
3	1	2	1		
4	1	2	2		
5	2	1	1		
6	2	1	2		
7	2	2	1		
8	2	2	2		
9	3	1	1		
10	3	1	2		
11	3	2	1		
12	3	2	2		

There are a several steps in the data collection process. The first step is to collect all of the data the radar is sending to the ROCC. The total amount of data will be used by the analysis to answer hypotheses one and three. Target counts will then be compiled using the software capabilities of the computers. The target counts will be used to answer hypothesis number two. Additionally, the target count data can be used to provide supplementary information concerning hypotheses numbers three.

IV. REVISED ANALYSIS PLAN

Balanced Analysis of Variance (ANOVA) will be used to analyze the data. The results will determine the outcome of the hypotheses tests. As indicated in the data section, there are two parts to the plan. The first section will use the balanced ANOVA to analyze the total amount of data. Thirty replications of each of the twelve trials will be made. This will be done to assume normality. The second phase of the analysis will also use balanced ANOVA, this time to analyze the thirty replications of target counts.

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